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British Foundrymen's Association (Birmingham Branch).—Discussion on "Moulding Sands," opened by J. Shaw (Dudley).

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British Foundrymen's Association (London Branch).—"Snap Flask, Plate and Machine Moulding," by A. R. Bartlett (Erith).

NOTES AND COMMENTS.

The Education Problem.

To those who have witnessed some of the problems presented during recent years by the development of popular education, it is extremely interesting to observe the present sudden demand for reform which comes from many quarters. The sleeping giant of public perception is stirring, and though not by any means awake and active, has yet reached the stage of imperative (and sometimes almost inarticulate) demands. But it cannot be doubted that the education question is being seriously considered in very many quarters which until quite recently ignored it; and the technical trades are among the foremost to stir in the matter. We revert to the subject at the moment on account of a Paper recently given before the Sheffield Branch of the British Foundrymen's Association by Mr. J. M. Fitzclarke, from which it is fairly obvious that previous discussions on the subject, which have been held a meetings of the Association, have not been entirely ignored. Mr. Fitzclarke appears to support the contentions regarding the tendencies of modern industrial development put forward in a Paper at the recent Annual Convention of the Association; but he goes further, and offers rather definite ideas on possible reforms. It is unnecessary here to review the speaker's remarks on the decline of the old apprenticeship system, the present position as regards the foundry, and the necessity of a radical revision of the existing system of education; they conform very closely to the contention already put forward in various articles in our columns. We may remark, in passing, that Mr. Fitzclarke supported the suggestion which we made some little while ago to the effect that the British Foundrymen's Association might institute examinations for foundry lads and apprentices, the passing of which would entitle them to a diploma, and that individual firms or groups of firms engaged in similar classes of work might act together in a scheme of vocational instruction and technical training. At the moment, however, we are more concerned with the definite scheme proposed by the speaker. This was briefly as follows:—

(1) That an advisory committee of manufacturers and skilled workmen working in conjunction with the educational authorities should inquire into and suggest any improvements in the subjects taught, according to the demands of the particular district being served.

(2) That no apprentices should be taken into any works under the age of 16 years.

(3) That the term of apprenticeship should be for four years and no less.

(4) That it should be a condition of apprenticeship that apprentices attend a set number of hours at approved classes having some bearing upon their employment.

(5) That teachers of trade subjects should be men of practical experience at such trades.

(6) That employers should offer facilities of time for attendances at trade classes without any stoppage of wages to students attending them.

(7) That the fees should be refunded to pupils making at least 85 per cent. attendances at classes and passing the examinations, and showing an intelligent interest and diligence in their work; and, further, that extra wages should be offered to youths showing special ability.

(8) That the advisability of making it compulsory for young persons to attend evening technical classes from the time of leaving school until 18 years of age should have careful consideration by the Government before drafting the proposed new Education Bill.

(9) That trade schools should be more generally established.

It will be observed that some of these proposals agree closely with those put forward in previous discussions; while many of them have been proved practicable to some degree, as will be seen by reference to a Paper on the subject presented at the Cardiff Convention of the British Foundrymen's Association. But when these proposals are collectively presented as a concrete scheme, however well they may have served individually, they call for serious consideration, particularly those of a restrictive nature, since they appear to be suggested for most trades and not only for the foundry trade.

Now it is probably a truism to say that no reform of a radical nature was ever initiated except by an extremist; in fact, in all movements a very positive scheme appears to be essential in order to break the first ground. But it is questionable whether the present situation calls for the same propaganda. It must be remembered that there is already existing a system of education which is unquestionably growing in an endeavour to meet the requirements of a complex industrial system, however inadequate and unsatisfactory that growth may be. Further, the requirements to be met are by no means simple, but rather highly complex and confused. When, therefore, one attempts to dogmatise one is constantly met with insuperable difficulties, which demand at least a compromise. In fact, it may be accepted at once that under modern conditions any reform is bound to result in a compromise between various opposing forces. We candidly do not care to face the possibility of such a rigid scheme of training, even for the technical trades. The most that can be done is to suggest the lines upon which improvement might be tried; but a set scheme under modern industrial conditions must inevitably fail to cover large sections of juvenile labour. It is to consider this problem in its relation to the foundry trade that the Special Committee of the British Foundrymen's Association has been formed; and until that Committee has gone thoroughly into present conditions and possibilities it is probably premature to attempt to formulate definite schemes. At the moment it is of more utility to collect information of a reliable nature as to what is being done in the matter of apprentice training and the instruction of boy labour, and what conflicting conditions will have to be accommodated in any scheme eventually devised. Restriction and compulsion in any form is only justified by good results, and care must be taken to ensure, so far as possible, those good results before the irritant (for such it essentially must be at first) is applied.

Possible Departures in Foundry Work.

The next few years will undoubtedly see a much wider application to the different requirements of foundry work, of materials which are at present not commonly so applied. Particularly will this be noticed in the pattern-making department. Plaster-of-Paris is, of course, not new in pattern-making, but it represents one direction in which great strides may be expected. Other compositions, also, which are at present quite foreign to this work, will unquestionably be found to have a real value for certain classes of pattern-making, and will be eventually accepted as standard materials.

But apart from those well-known materials for which ordinary common-sense might suggest applications, there are other materials of a less well-known nature which have an undeveloped field before them. There are considerable possibilities in the production of metallic forms of an intricate nature without melting the metal—castings, if the term may be so extended, without melting. For example, while in recent years it has been discovered that by the addition of certain substances to molten metal its fluidity can be increased, or at least prolonged, it has also been discovered that when metals or alloys in a very freely divided state (sometimes with the admixture of other materials) are mixed with dilute acid—for instance, sulphuric acid of a specific gravity of 1.2, or acetic acid—so as to make a more or less stiff emulsion, the mixture will harden gradually without shrinking; the resulting mass being durable and capable of being polished. As this mass may be cast even in glue molds, and is not addicted to forming blow-holes, there may be made therefrom art objects which are said to be equal in polish and colour, even superior in the latter quality, to the ordinary "hot" castings. The powder—lead, zinc, tin, etc.—is produced by electrolysis. Among the substances which may be added with advantage are pumice-stone, ashes, sand, wood-flour, etc. Instead of dilute acid there may be employed an acid solution, as for instance acetates, alkaline bisulphates, etc. The necessary strength of the solution depends on the desired speed of setting. The use of such a process when reduced to a commercial basis, in the production of permanent patterns, core boxes, pattern-plates and similar work, is obvious.

Another process which may be said to have similar appreciations is based on the fact that different metallic mixtures, in passing from the liquid to the solid form, remain for a time in a doughy condition. This dough may be mixed with either metallic or non-metallic substances, thus obtaining alloys or mixtures which may be mixed with other materials in a very finely divided state. A third process starts with a very finely divided mixture of sand and metallic powder, mixed with absolutely pure sulphur, and heated. A suitable mixture of this class is obtained by blowing sand at a high velocity against a metal plate, as for instance one of cast iron. Although these three processes have not yet found a very great practical application, there are undoubted possibilities before them, and it is not too much to expect that in the near future their value will be turned to general practical account.

The Electric Steel Furnace.

In a Paper on this subject read before a meeting of the Association of Iron and Steel Electrical Engineers, New York, Mr. Wilfred Sykes stated that during the last five years the production of steel by electric furnaces in the United States and Germany, which countries are the principal producers, has been as follows:—

Year.	United States.	Germany.
	Tons.	Tons.
1908	55	19,500
1909	13,762	17,700
1910	52,141	26,200
1911	29,105	60,600
1912	18,309	74,200

The Annealing of Steel in Continuous Furnaces.

By Harry Brearley.

Some twenty years ago or less the annealing of steel castings was carried out mainly with the idea of removing dangerous stresses set up within the metal during its passage from the fluid to the solid state and from the hot solid condition down to normal temperatures. The annealing process consisted, therefore, of re-heating the castings to a low red heat, keeping them at that temperature for varying lengths of time, sometimes as long as 30 or 40 hours, and then allowing them to cool very slowly. Altogether, including the charging and emptying of the furnace, the annealing operation would occupy the best part of a week.

On examining old steel castings which have undoubtedly been annealed in the above manner, one observes that they are very soft, that a sound tensile test piece cut from them will give excellent elongation and that, the excellent elongation notwithstanding, the material is brittle under shock tests. When examined microscopically the original castings structure is found to be in an almost unaltered condition (Fig. 1), and at comparatively low magnifying powers the pearlite areas are well laminated. (Fig. 2.)

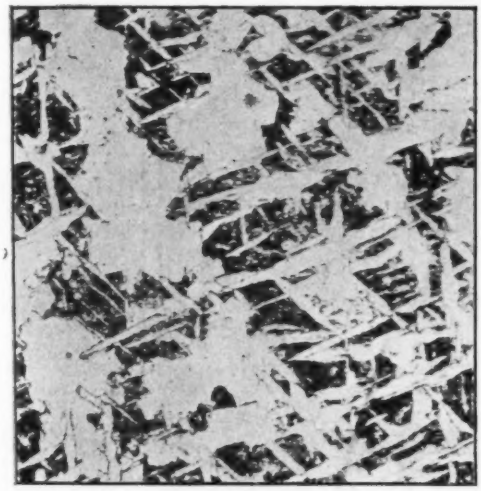


Fig. 1.—Microstructure of Annealed Casting Made 20 Years Ago; Magnified 20 Diameters.

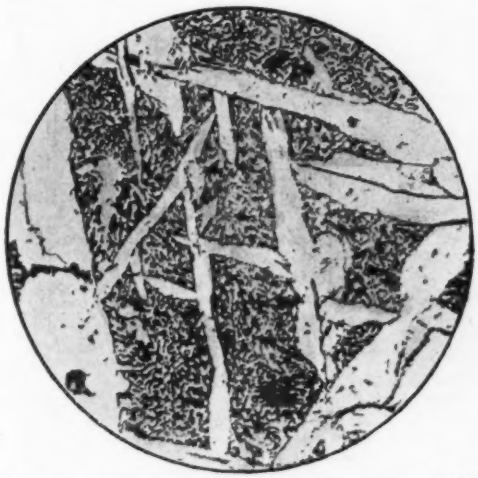


Fig. 2.—Same as Fig. 1, but Magnified 100 Diameters.

From the conjoint use of the pyrometer, the microscope and various means of mechanical testing, it became clear that the re-heating operation generally described as annealing could be utilised for other purposes beside relieving dangerous stresses in the metal and increasing its softness. The most remarkable change which might thus be brought about was the almost complete obliteration of the characteristic "casting structure" and its replacement by a finely crystalline material such as had formerly been associated only with forged or rolled steel, obtaining at the same time a material which resisted shock stresses very much better than the earlier-made material. Fig. 3 represents the variation in structure attained by the older and new methods of annealing.

Whereas in the older methods of annealing a low red heat—say between 750 deg. and 800 deg. C—was used, the newer method required the castings to be exposed to temperatures between 850 deg. and 1,000 deg. C., according to the composition of the steel from which they were made; the higher temperatures being used for the lower-carbon steel. As, however, the high-temperature annealing does not markedly affect the results of tensile test as generally specified by consulting engineers, the newer methods of annealing were not immediately and unanimously adopted; the reasons being increased cost of fuel used in the annealing process, greater loss of steel and increased cost of fettling owing to the formation of thick, hard scale on the surface of the casting, and the greater danger of distortion in delicate castings.

Whatever temperatures are employed, that portion of the heat required to raise the temperature of the furnace walls, etc., is lost during the subsequent cooling down. This loss is greater the higher the temperature used; the time required to cool to normal temperatures is also greater and so also is the wear and tear of the furnace parts. It is not difficult, therefore, to understand why an undoubted improvement which was not clearly reflected in the accepted quality of the goods but whose influence was adversely felt in the cost of production should make slow progress.

From furnaces provided with bogie hearths the castings could be either withdrawn at their highest temperature into the air, which was permissable only in rare cases, or they could be pushed into a chamber adjacent to the annealing furnace and there be allowed to cool off slowly during the time a second charge was being heated. This is the nearest approach to continuous annealing at present in use, and it can

be applied with obvious economy only to large furnaces.

As some compensation for the increased cost of attaining high temperatures, the time during which the castings were exposed to those temperatures has been gradually reduced; but it is still necessary in annealing large numbers of castings simultaneously to keep up the furnace temperature during many hours in order to ensure that each piece gets heated to the required minimum temperature; and it requires considerable care at the same time to avoid overheating those pieces lying in certain other parts of the furnace.

Where a small casting is heated separately, the time required to break down the coarse crystalline structure and replace it by a much finer one (compare Fig. 3), providing the required minimum temperature has been exceeded, is not great; no longer, in fact, than may be required to attain a uniform heat throughout the castings. It appears, therefore, on the face of it that an arrangement whereby steel castings could be gradually heated to a maximum temperature and gradually cooled off without being maintained for any length of time at the maximum temperature might be found both an effective and economical method of annealing.

An arrangement of the kind indicated is in use in the pottery trade for glazing tiles and firing green earthenware. It consists of a long tunnel oven, or furnace, a section of which is heated to the required temperature and through which trucks on roller bearings and carrying goods to be fired can be propelled. A section of the oven as used for tile glazing is shown in Fig. 4. The oven is fired with producer gas and the temperature near the combustion chamber, according to automatically-registered pyrometer records, can be kept practically constant for months on end at any temperature up to 1,250 deg. C. The author is obliged to Mr. Conrad Dressler, the inventor of the oven, and to Messrs. J. H. Barrett & Company, Stoke-on-Trent, for permission to treat a small batch of steel castings in such a furnace.

Two kinds of castings were placed on a truck which moved slowly along with the rest towards the combustion area. Slowly and uniformly the temperature of the castings rose up to 950 deg. C., and then at the same rate the temperature decreased as the truck moved away from the combustion area; at the end of the journey through the oven, which occupied 27 hours, the castings were notched and broken in order to expose a clean fracture from which might be judged whether the coarse crystalline structure had been refined. One of the steels contained:—Carbon 0.10, silicon 0.17, manganese 0.19, sulphur 0.020, phosphorous 0.052. It had a very coarse structure before treatment, but was found to be satisfactorily refined. (See Fig. 5.) Its resistance to shock stresses before and after treatment, as determined by a notched-bar one-blow impact test, was:—

Before treatment:—11 ft. lbs.: Repeat 5 ft. lbs.

After treatment:—46 ft. lbs.: Repeat 50 ft. lbs.

The second steel was an alloy steel characterised by very large crystalline structure as cast. It also was completely refined, as will be seen in Fig. 6, which represents fractured surfaces before and after treatment.

From time to time the user of steel castings is informed that castings made by this or that process can be safely used without annealing. At least two University Professors have been found to give their blessing to such claims, but they are none the less mischievous on that account. One of the latest adherents to this view is Dr. Héroult, who claims that "in the case of many low-carbon high-quality castings made in the electric furnace it is unnecessary to anneal them." As a matter of fact, the necessity for annealing is mainly independent of how the steel has been melted; it is really due to changes which take place after the steel has left the furnace and is already in the mould, *i.e.*, the types of structure developed, according to rate of cooling as the hot fluid steel becomes solid and cold.

But if the annealing operation is going to take the best part of a week, there is every reason to look favourably on any process of steel melting which claims to render it unnecessary. Such claims are, in the nature of things, unjustifiable, and those manufacturers who wish to speed up the delivery

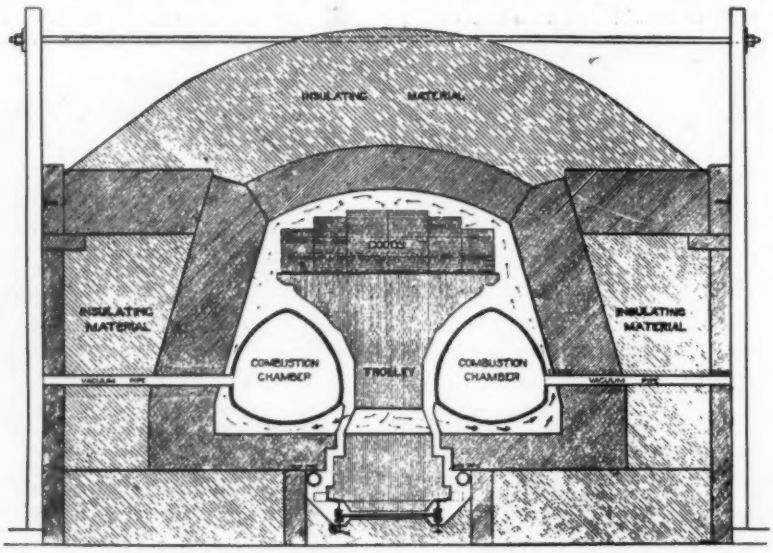
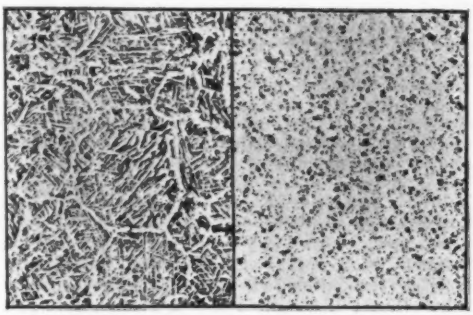


FIG. 4.—SECTION OF DRESSLER TUNNEL OVEN.

of castings can safely do so, not by omitting the annealing process, but by shortening it. It may be feasible to heat and cool steel castings with greater liberty than is possible with earthenware, and possibly a tunnel oven could be made to do effective annealing in ten or twelve hours. In that case the output would also be increased and the cost reduced.

As to the annealing of steel in general, apart from steel castings, it may be pointed out that the steel only and part of the truck are heated and cooled. The furnace itself is kept at a constant temperature, which is very favourable to its durability. Very little heat is lost, as the waste products of combustion heat up the trucks from the incoming end and



Old Method. New Method.
Fig. 3.—Comparison of Effects of Annealing.

the trucks which have passed the combustion area give up their heat to the air which is to be used for burning the producer gas. Economy could scarcely be more complete.

The producer gas burns inside thin-walled chambers which run each side along the entire length of the oven, and the products of combustion are drawn into the stack by a fan. The atmosphere of the furnace, therefore, is not disturbed by waste gases and may be made either oxidising, reducing or neutral at will. For pottery purposes it is important that

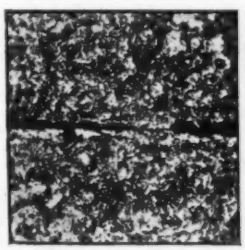


Fig. 5a.—Fractured Surface of Mild Steel Casting before Annealing.

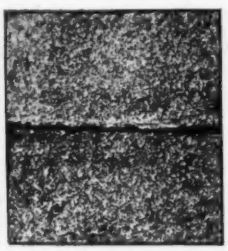


Fig. 5b. Fractured Surface after Passing through Dressler Oven.

the atmosphere should be dry and free from sulphurous fumes and dust; for the annealing of bar steel, drawn tubes, cold-rolled strips, wire coils and many other products it is of prime importance that the atmosphere should produce no scale nor even tarnish the bright surface of the goods. That seems possible in a tunnel oven, but it has not yet, so far as the writer knows, been tried.

Uranium and Tantalum in Steel.

Uranium is one of the rare metals. The ores of uranium are the source from which radium—the rarest and most expensive element known—is extracted, and the preparation of ferro-uranium for steel-making is a costly and difficult problem. The difficulty of obtaining a suitable ferro-uranium has undoubtedly retarded experimental work in uranium steels, but work has been done on the Continent and in America which has led to great hopes for such steels.

Ordnance and high-class steel makers have hesitated to use ferro-uranium, as they have feared that a regular supply would not be assured, but Messrs. Geo. G. Blackwell, Sons & Company, Limited, of Liverpool, now inform us that they are interested in radium, their chairman also being chairman of the Radium Mining Extraction Company, Limited, which owns uranium ore mines. Messrs. Blackwell are marketing ferro-uranium for steel-making, and

Fig. 6a.—Alloy Steel Casting as Cast.

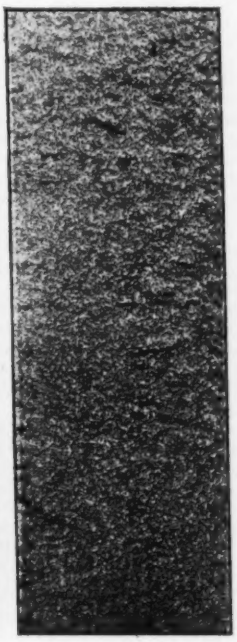


Fig. 6b.—Alloy Steel Casting after Passing through Dressler Oven.

no doubt a series of investigations will be made by English steel-makers with this interesting element.

For several years tantalum has been used in steel manufacture, and steels of extreme hardness can be produced by its use. Hitherto the high price of ferro-tantalum has prevented its extended use, but Messrs. Blackwell are now marketing it at a much reduced price; in fact, substantially below the price of vanadium, so that its extended use is now commercially possible. Messrs. Blackwell have consistently urged the advantages of molybdenum even so far back as 15 years ago, and the demand for ferro-molybdenum has now far outrun the supply, owing to the scarcity of ore.

Iron: Its Sources, Properties and Manufacture.

By A. E. Timmins.

In the course of an address on this subject before the Lancashire Branch of the British Foundrymen's Association, on November 1, Mr. J. Simkiss in the chair, Mr. A. E. Timmins said :—

The smelting of iron ores in the blast furnace with the production of pig-iron, forms the fundamental basis of the manufacture of iron, and on the success of this operation depend both the quality and cost of the product—whether it be iron or steel. The procedure varies with the raw material used, the class of iron to be produced and local conditions, different districts having different methods. Further, no two furnaces, although built on similar lines, and working under practically the same conditions, behave exactly alike; while also difficulties arise which can only be remedied by the man on the spot who knows the conditions under which they were brought about and the working of the furnace. It cannot be too strongly impressed that no hard and fast rules can be followed in working a blast furnace, and that theory and practice are sometimes apparently at variance one with another. It is only by close and careful attention and practical experience that success is attained.

Iron Ore.

Some deposits of iron ore may be looked upon as iron rust, more or less altered in composition by heat, and which have become naturally mixed with widely varying amounts of other matter, such as silica, clay, calcic phosphates, etc. The "other matter" constitutes the gangue of the ore, and the gangue usually requires some flux to accompany it in the blast furnace. For example, silica (SiO_2), which forms such a large percentage of the gangue of many ores, is quite infusible even at the very high temperature of the blast furnace, but at that temperature the silica may be caused to enter into chemical combination with the flux so as to form a fluid compound and be tapped out as slag.

The ores of iron which are smelted are all essentially oxides of iron mixed with gangue, and they all contain phosphorus. They may be classed conveniently thus :—

Ferrous Ores—	Ferric Ores—
Blackband ironstone.	Red hematite.
Clayband ironstone.	Brown hematite.
Cleveland ironstone.	
Spathic iron ore.	Ferrous Ferric Ores.
	Magnetite.
	Franklinite.
	Ilmenite.

Magnetites.—When pure, magnetic oxide of iron (Fe_3O_4) is the richest iron ore, containing 72.4 per cent. of iron, and is in the form in which the iron occurs in some of the most extensive and valuable deposits in the world, *e.g.*, the magnetites of the Lake Superior district of North America, and the very pure ore from some of the noted mines of Norway.

Red Hematites.—Ores which contain their iron in the form of ferric oxide are, broadly speaking, of two classes, viz., those in which it occurs as the anhydrous oxide, *e.g.*, red hematite and those in which it occurs as hydrated oxide, *e.g.*, brown hematite. The red hematites, which are usually very free from sulphur and phosphorus, require no preliminary treatment before smelting. Iron made by smelting red hematites or other pure ores is commonly known as hematite iron, and is used principally for making Bessemer pig-iron. In this country the red hematites of Cumberland and Lancashire are well-known as producing hematite iron of the best quality.

Brown Hematites.—These ores constitute one of the most abundant sources of iron in this and other countries. They are usually found more or less phosphoric, the iron being used chiefly in the foundry. The amount of water present varies, and there is no very sharp line of division between red and brown hematites as regards general appearance. There are many intermediate varieties between the typical hard, dense, red hematites of a dark red or almost black colour, and the soft, friable, brown hematites (limonites) of a light yellowish brown colour. Brown hematites are often calcined to drive off the water, and the calcined ore then has a red colour.

Spathic Ore.—In this ore carbonate of iron ($FeCO_3$) occurs in a state of relative purity, and forms large and important deposits. In Germany spathic ore is usually low in sulphur and phosphorus. Manganese is often high in spathic iron ore.

Clay Ironstone consists of carbonate of iron mixed with more or less clayey matter. It is usually found in beds in coal measures, and is mined with the coal, although the best known and largest deposits are found in the Cleveland district. The coal-measure clay ironstones contain about 0.25 per cent. phosphorus, and give pig-iron particularly suitable for the production of good or strong castings. Sometimes the clay ironstones are found containing considerable quantities of carbonaceous matter, are black in colour, and known as blackband ores. They may usually be calcined without extra fuel, as in the case of North Staffordshire. The Cleveland ironstone, which contains about 33 per cent. of iron, is much more phosphoric, and the iron made from it contains about 1.6 per cent. of phosphorus.

Preliminary Treatment of Iron Ores.

It is in some cases profitable to adopt special means to concentrate the ferruginous material in the crude ore and to separate it from impurities, as in the case of certain magnetic ores, but usually the ore either undergoes no preliminary treatment before smelting or is merely calcined.

Calcination has for its objects the driving off of carbon-dioxide, water, sulphur and other volatile substances, and more important still, the conversion of ferrous oxide into ferric oxide. Carbonate ores, such as clay ironstones and blackband ores, are always, and brown hematites generally, calcined. Magnetites and red hematites seldom need this treatment, and are usually smelted without preliminary treatment. In certan cases, *e.g.*, blackband ores, they are calcined in open heaps, but usually the operation is carried out in specially-constructed kilns, using coal, or in some cases gas, as fuel.

Smelting of Iron Ores.

The blast furnace is the most compact and efficient erection for cheaply and quickly treating large quantities of heavy materials. The solid materials charged are: (1) The ore from which the iron is to be extracted; (2) the fuel required to carry on the work; and (3) the flux which on uniting with the impurities in the ore and fuel causes the formation of fluid compounds. These solids are delivered at the top of the furnace and in due course descend. A strong air blast is injected near the bottom of the furnace where the fuel is burned. The products of the blast furnace are pig-iron, slag and gases.

The Blast Furnace.—This is of the type known as shaft furnaces, in which the fuel, ore and fluxes are in contact. The furnace consists of an outer shell of steel or iron plates lined with firebrick and supported on a ring which is carried by cast-iron columns. The top of the furnace is usually closed by a cup-and-cone charging arrangement. The charge is placed in the cup and admitted to the furnace by lowering the cone or bell. Except for a very short time during charging, the furnace is thus kept closed and the gases pass off through the downcomer and are burnt partly in the stoves to heat the blast and partly under boilers to raise steam, or after suitable cleaning are used in gas engines for power purposes.

The blast enters the furnace through tuyeres which are usually six to ten in number, after being heated in the hot-blast stoves, except in very special cases where cold-blast iron is being made. The pressure of the blast varies considerably according to the construction of the furnace, character of the charge, etc. In the Barrow district anything from 3 to 9 lbs. is found suitable. The temperature of the hot blast is between 300 to 700 deg. C., but lower temperatures are sometimes used. The molten iron is periodically withdrawn from the hearth of the furnace through the tap hole, and the slag is allowed to run almost continuously through the slag-notch, which is at a higher level. The solids are soon acted upon by the hot reducing gases, but it is not until the hottest zone of the furnace is reached that the reduction and separation are completed.

The reduction may be, and is, effected in three ways:—(1) By oxidising the carbon of the fuel at the tuyeres to carbon monoxide by the oxygen of the blast, and the carbon monoxide thus formed taking one atom of oxygen from the ore, forming carbon dioxide. This reaction is exothermic, *i.e.*, gives out heat. (2) By the direct union of the carbon and two atoms of oxygen from the ore, forming carbon dioxide. (3) By the carbon taking directly one atom of oxygen from the ore, carbon monoxide being formed.

The last two reactions are endothermic (*i.e.*, absorb heat), and for this reason the first should be aimed at. It cannot, however, be fully realised, as the conditions under which reactions (2) and (3) are brought about, viz., contact between fuel and ore, cannot be avoided entirely.

For hematite and non-phosphoric foundry iron, Cumberland and Spanish hematites are suitable, and for foundry (general) iron Cleveland and Northampton ores, puddlers cinder, etc. The ore should be high in iron, contain sufficient silica to form a slag, be low in sulphur, phosphorus and manganese (if for hematite). For all classes of iron the ore should be free from copper, chromium, arsenic, etc., or at the most have only a trace.

Refractoriness and Physical Condition of the Ore.

The refractoriness of the ore is of great importance, as on it depends to no small extent the consumption of fuel. Further, smelting together of refractory and easily reducible ores may give rise to iron of inferior quality. The proportions of lump, rubble and fine are also of importance. If fine, loss may occur through ore being blown away on lowering the bell, by being carried over by the gases into the flues, etc. Fine ores have a tendency to cause irregularities in working. Uniformity is of great importance. The supply should be regular and constant. Frequent change of burden through shortage of supply and change of brands leads to irregular working.

Fuel.

Coke is the fuel most generally employed. Chemically, the coke should not contain more than 1 per cent. of sulphur, 10 per cent. of ash, and for hematite iron not more than 0.015 per cent. phosphorus. Physically, it must be thoroughly coked, hard, dense, free from small (breeze) and sponginess, and of sufficient strength to carry the weight of the ore etc. without crumbling, so that any reaching the tuyeres should not be in a fine state of division.

Flux.

As a flux limestone is generally used, and its value as such depends on the available lime it contains, that is, the lime in excess of that required to flux its own silica, etc., and freedom from sulphur and phosphorus. A good limestone contains about 54 per cent. of lime (CaO). The presence of much magnesia in the stone tends to make the resulting slags less refractory. The limestone should be of fairly uniform size.

Slags.

Slags are very important factors in blast-furnace practice. Any change in the working of the furnace is quickly indicated by change in the appearance of the slag. Also, different grades of iron have different slags. Slag is the substance that requires the greatest heat for melting; it therefore follows that if the temperature is sufficient for this the other materials must be properly melted and that the slag affects the grade of iron by influencing the temperature. Of the descending materials in a working blast furnace, all that retain their oxygen go into the slag (and with the exception of some sulphur which is collected in the slag) all that are reduced go into the pig-iron.

[The lecturer then proceeded to discuss the chemical reactions in the blast furnace.]

Pig-Iron.

A blast furnace which is working on a light burden or at a high temperature produces as a rule, grey pig-iron, with much carbon and silicon and in which most of the carbon is made to pass into the graphitic state. On the other hand, a blast furnace which is working on a heavy burden or at a comparatively low temperature generally produces a white pig-iron, one containing less C and Si and in which the carbon is chemically combined with the iron. Grey iron has a higher melting point than white pig-iron and more heat is required to melt the grey variety, but when melted grey iron is more fluid than white. Melted grey iron expands just before solidifying. This enables it to take a sharp impression when cast in a mould, hence it is most suitable for fine castings. White pig-iron does not so expand before beginning to solidify. During melting, white pig-iron passes through a pasty stage favourable to puddling.

The chief characteristics of grey and white pig-iron from an ordinary blast-furnace burden for foundry or forge may be conveniently summarised

and compared thus. It must be distinctly understood that we are considering the characteristics of average pig-iron of each kind, and that there are exceptions, for, under certain conditions of management and driving not known to the founder who uses the pigs, the fracture gives but little indication of the composition of the pigs, *e.g.*, sometimes the grey iron from a blast furnace actually contains less silicon than a white pig-iron from the same or a previous cast.

Grey Pig Iron.	White Pig Iron
Contains much carbon. Most of the carbon is in the graphitic state.	Most of the carbon is combined.
Contains a high percentage of silicon.	Does not contain so much silicon.
Contains much manganese	Does not contain so much manganese.
Contains little sulphur	Contains more sulphur.
Average specific gravity about 7.1	Average specific gravity about 7.5.
Is large-grained (open-grained) grey, soft and tough.	Is fine-grained (close-grained) white, hard and brittle.
Melting point about 1,400°C.	Melting point about 1,300°C.
Is more fluid when melted than white iron	Is not so fluid when melted as grey iron is.
Expands just before solidifying.	Passes into a pasty condition when below its melting point.

Discussion.

Mr. Markland said the reader of the Paper made a remark to the effect that they could not judge iron from a fracture. He would like to ask, supposing the metal which had been poured into chills was re-melted, would it come out of the cupola as white iron? He had asked that question before, and it had been answered in two ways.

Mr. H. Sherburn said the matter that specially took his notice in the Paper was the casting machine. At their last meeting there was some discussion about the casting of pig-iron, as some of it was cast to-day, in permanent moulds. The ingot-casting machine was brought out for one reason—to obviate the large amount of sand that was on sand-cast pigs. They could see from the construction that it was an expensive machine, and it was not likely that iron makers would put down a machine of that description simply for the advantage of foundrymen. Then they had to remember that a large proportion of the pig-iron that was manufactured to-day was made for steel, the foundry trade only taking a small quantum of it. The steel makers were very keen upon going into analysis, and, as the lecturer had pointed out, the furnaces did not work with absolute uniformity; there was consequently a large amount of doubtful pig-iron produced which somebody had got to have. Under present conditions the foundries got it, and the only means by which they could get out of that system would be by the foundries co-operating in some way and approaching the pig-iron manufacturers as one body, just as the steel makers did, and insisting that they should have iron equal to that which the steel makers got, for they knew they did get it.

Mr. Cordingley said he could not follow the lecturer in his observations respecting manganese.

Mr. Andrew contended that in regard to the fracture of pig-iron the conditions varied and so produced different fractures. In referring to the casting machine, Mr. Timmins stated that fracture was no indication of chemical composition. If he was referring to pig-iron on the pig bed he would accept the statement, but he would like to ask if he would not expect wide differences in the appearance of, say, No. 1 iron and No. 4 iron cast in the same chill. If there was a difference the fracture must give an indication of the iron.

Mr. Penlington said Mr. Timmins had missed explaining or giving any reason why the form of the blast furnace had been kept pretty much the same ever since its inception. There had been improvements no doubt, but they had been mostly in the way of catching the gases and diverting them to other uses; labour-saving rather than for the better production of the pig-iron. The various oxides and di-oxides and monoxides were always there, but they were in such varying proportions and so uncontrollable that until the pigs were broken up it was impossible to tell what was going to be obtained. It was quite true that the foundry got the pig-iron which was unacceptable to the steel makers, but then there was no one else to get it. The coke had much to do with the making of pig-iron, and many firms were making their own coke because it was profitable to do so, and because they could make it to suit their own purposes better than they could buy it.

Mr. W. H. Sherburn said one thing which had struck him while Mr. Timmins was reading his Paper, as it had struck others, was the point of cooling, both on the pig bed and on the casting machine. He would like to ask the lecturer if he ever knew, say, No. 1 made with the machine where the iron went through the water, or any No. 2 either, or any of the soft-grade irons—what effect had the cooling of the water on the pig-iron? Was it that No. 1 was made into something else by the hose?

Mr. Hogg wished to know why the pig-iron of to-day was inferior to the pig-iron of many years ago. He had often heard it said that the pig-iron they got 20 years ago was far superior to that which they obtained now. Old foundrymen told them there was no trouble in those days in mixing their pig-iron.

The Chairman then read an extract from a contemporary, which discussed the Héroult electric furnace, which was erected near Shasta, California, for the direct production of pig-iron from the ore by electric smelting. It was stated that the difficulties experienced had now been overcome, and a commercial product put on the market. Owing to the low sulphur and phosphorus, the chief constituent apart from iron and carbon was silicon, and the irons were graded into twelve classes according to the silicon, which varied from 5 to 1 per cent. The irons were mainly used in the Western American foundries, and from the analyses seemed of high quality. He then asked Mr. Timmins what constituted the great differences in buying irons. He had with him two analyses which varied very little indeed, and had the same breaking stress, but the prices were very different. Then he would like to ask whether the carbon was the same in one iron as in another, irrespective of the districts in which the ores were produced? Was it possible to get satisfactory pig-iron from analysis without taking into account fracture also? Then, again, was it possible to forecast the breaking stress of any given mixture of pigs taken from analysis?

Mr. Timmins, in replying on the discussion, said with regard to Mr. Markland's question as to whether chilled pig-iron when it is re-melted, passed out as white iron, he would like to understand what it meant. There were two schools of opinion on the question, and they differed, but he thought if the carbon was in solution they could not bring it back again. Mr. Sherburn had spoken about the quality of the iron sold to the foundries, and remarked that somebody had got to have the "doubtful": he could only say that if doubtful iron were supplied to him he should know what course to adopt. With respect to Mr. Cordingley's observations concerning manganese and sulphur, he could only say that he

stood by his statements in the Paper. Mr. Andrew had drawn attention to the wide differences in appearance between No. 1 iron and No. 4 when cast in the same chill and in the same mould. He could only say he thought No. 1 iron would be far superior to No. 4. He had been asked why the pig-iron of to-day was inferior to that of twenty years ago; they must remember that where 20 years ago they would make 50 tons, they had now to make from 350 to 400 tons.

Moulding a Cylinder in Loam.

At a meeting of the Halifax and District Branch of the British Foundrymen's Association, held in the Municipal Technical College, on Saturday, October 18, Mr. Milligan in the chair, Mr. S. G. Smith gave an illustrated lecture on "Moulding an Internal Flanged Cylinder in Loam." This procedure has already been dealt with in an article by the lecturer in our columns. (See March, 1912, page 156.)

Mr. Smith said the type of casting chosen for description was made up to 10 ft. in diameter in one piece and of varying lengths. They were often strengthened internally with additional flanges and ribs. The design of the one to be described was as plain as could be made, and was chosen for description to avoid complexity.

Continuing, Mr. Smith said:—There is little in common between sand moulding and loam moulding, except that each method forms a mould. A loam moulder's daily routine is with spindles, plates, bricks, straight-edges and square striking boards and strickles, etc. A sand moulder's daily routine is with patterns, boxes, rammers, etc. When making a casting in loam, whether it be large or small, the tackle is the most important, and if the casting is a difficult or intricate one to mould, there is more reason for forethought. It is at this point where ingenuity needs to be displayed by the pattern-maker and moulder. As far as possible, the work is laid out full size in the pattern shop, and the moulder, with the aid of the patternmaker, gets the dimensions for his tackle for the job. The essential points for the moulder to watch are correctness of sizes, strength of tackle (make it strong enough) and to take care provision is made for runner gates and risers, bolting up and vents. Provision must be made for easing or liberating after pouring, and for the contraction of the casting. Should more than one casting be required, the tackle should be made, where practical, so that it will carry the work through. By considering these points, which often demand much foresight on the part of the moulder and patternmaker, much valuable time and expense are saved.

Special stress may be laid on the point that within reason it is preferable for a moulder to err on the heavy side than the light when tackle making, because the breaking of a plate, binder, staple or bolt often means beginning again, beside the possibility of injury to the workmen. All cake plates should be regularly prodded and ample vent holes cast in, care being taken not to unduly weaken any part.

The stability of loam moulds where much walling is required depends upon how the brickwork is done. Faulty bricking can cause such evils as swells and irregularities, and in some cases moulds and cores have collapsed before stoving. The bricks should be placed in such a manner as to bind and support each other, each joint being covered by the next course of bricks. Binders are necessary at intervals to support the brickwork during slinging, drying, etc. The loam used should be of a medium stiffness with plenty of opening material in it. In dealing with venting, the generation and expansion of gases during pouring, make it necessary to provide channels for the rapid escape of the gases. For example, when a flat surface forms part of the mould, the bricks should be from half-an-inch to one inch apart, with no loam between them, the open spaces being filled with ashes to the level of the bricks. Escape from the cinders is also provided for by the laying of straws on the bottom plate before the loam is put on for the first layer of bricks. Other things conduce to the escape of the gases, such as holes in the bottom plate, and through the joints of the outside row of bricks. It does not matter what means are adopted, providing the air is allowed to escape quickly enough to prevent scabbing and blowing.

In the dressing of a large loam mould, or core, the checking for sizes should not be done when very hot. It can readily be seen that if dressed in that state and not cast till it is only warm, the sizes of the casting will not be accurate, as contraction will still proceed. It is unwise to black-wash when very hot; a result of so doing often shows in loam cracks, and wet markings will develop on the casting which are invisible on the mould. This is quite apart from the loam cracks, caused by strong or weak loam. Although the cause of this phenomena is not quite clear it seems reasonable to suppose that when the black-wash is applied to the hot loam, steam is generated and penetrates through the thickness of loam to the brickwork, pushing the loam slightly away, and in the course of casting the pressure of the metal forces back the loam, causing irregular markings, which disfigure the casting when dressed off.

In the discussion that followed, Mr. Berry said that he had not a large experience of loam moulding, but he remembered some annealing pans being made and a cast-iron outside was used. This struck him as being a quicker method than the one described by Mr. Smith, and when these castings were taken out the mould looked almost good enough to re-black for another casting. Also, he had not altogether fallen in love with the method of lifting by the centre spindle. It struck him it would be bad for levelling, and the alternative method shown by Mr. Smith, where the core was lifted by four staples attached to the bottom plate, seemed the easier and simpler method.

Mr. Carrick said the lecture would certainly be very instructive to many, as for every shop where loam moulding was done there were probably 30 where there was no loam moulding. Somehow moulders seemed to fight shy of loam moulding, but speaking for himself he found it most interesting; it was certainly safer, but it required a knowledge of drawings and tackle.

Mr. Smith, in his reply, explained that once the brickwork had been built up with the wrought-iron rings around, it was a permanent structure, and only needed the loam scraping off and striking up again for another mould. There was something to be said for Mr. Berry's method; he had made castings weighing up to 5 tons in a similar way, but it was a hot job, and he preferred the other way. As for lifting the core by the centre spindle, it needed no levelling, it levelled itself and only needed guiding to its place. In reply to Mr. Carrick, there were moulders who understood both loam and sand moulding, but were fast becoming a rarity, and the difficulty seemed to him to increase, as boys were nowadays difficult to get in the foundry. He did not fancy dabbers at all. They were all right where only one casting was required, but rings were much better for many castings.

The Centrifugal Blower for Foundry Use.

By Dr. Richard Moldenke.

While the many advantages of the centrifugal blower, or compressor, for foundry use are manifest, as, for instance, steadiness of the blast pressure and volume, minimum horse power required, and maintained efficiency in operation, one does not hear of its introduction into our foundries at any great rate. It may, therefore, be of interest to glance over the results of an efficiency test made with a blower of this type (the Rateau) built by Kuehnle, Kopp & Kausch, of Frankenthal (Palatinate), Germany.

Everyone in these days knows what a steam turbine is—the steam being allowed to impinge against a series of blades of suitable curvature around the periphery of a fly-wheel and thus turning force to motion. In the case of the centrifugal blower or compressor, the case is practically reversed, and the turning of the fly-wheel provided with sets of blades of suitable curvature draws in the air, compresses it, and discharges it steadily and efficiently. Depending upon the number of these wheels side by side, each one giving the air an additional compression, there will be a given pressure resulting. Variations in speed mean higher or lower volumes and pressures, and taken as a whole, the machine is a beautiful

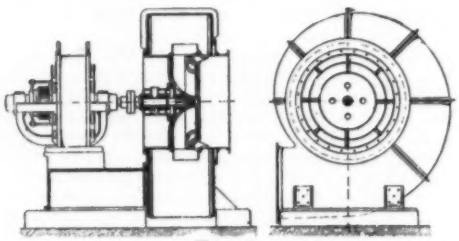


FIG. 1.

piece of mechanism. Either a motor is attached to run the apparatus, or else the shaft is continued and a steam turbine forms the other end.

Fig. 1 shows the section of such a centrifugal blower, and Fig. 2, the curvature of the blades. This system of blowing has, so far, been used more particularly for the blowing engines of blast furnaces (up to 15 lbs. per sq. in. pressure) and also in the compound stages for regular compressor work with 80 lbs. and above per sq. in.

If it is remembered that because of its construction there is no rubbing of the blades against surfaces to keep the machine tight, but that there is clearance all over, it may be understood why the consumption of power is so low, the action being somewhat like the fan in this respect, but positive. The methods of construction are such that air enters very direct, without chance to form whirls, and after compression leaves the machine under the best conditions.

In the test in question there were taken two of these Rateau blowers, the diameter of the rotating impellers being 40 in., the volume delivered constantly 19,500 cub. ft. per minute, with variable pressures from 2 to 6 in. of water. The blowers were operated by a 30-h.p. motor, which, for purposes of the efficiency tests in question, could be run at a variable speed of 650 and of 1,000 r.p.m., direct connected. The air pressures were measured at points where reliable results were certain, and the currents observed by using bundles of silk thread, the flow being thus readily indicated. A Robinson anemometer was used to get the air volumes.

The curves obtained from the several tests made have a peculiar shape, and there can be noticed at once that for every speed of the blower as well as for every pressure, there is a given air volume at which there is obtained a maximum efficiency. Furthermore, when running at constant speed, and with variation of air volume taken and delivered (by means of blast gates) the portion of the curves denoting maximum efficiency is so extended that a comparatively wide range of air volume is allowable without loss in effective use of power.

From the curvature of the blades (Fig. 2) it will be noticed that air can enter from within under conditions of greatest ease and without obstruction, while on leaving the blades there is but an angle of ten degrees made with the diameter of the rotating impeller In the tests in question, with constant volume,

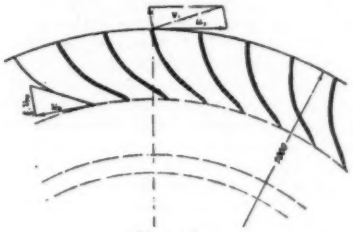


FIG. 2.

the air pressures were intended to vary, in order to determine the efficiency of the apparatus. Hence it will be readily understood that to produce the higher pressures required more horse power. The actual efficiency varied as follows:—For 2-in. water gauge it was 73 per cent.; for 2.6-in., 74.5 per cent.; for 3.2-in., 75.5 per cent.; for 4.2-in., 77 per cent.; for 5.2-in., 75 per cent.; and for 6.2-in. water it had dropped down to 71 per cent.; all of which indicates a very small variation in efficiency for this type of machine for work against varying pressures for a constant volume production. This is important for the foundry, as here it is absolutely necessary that the blast, or air volume, be constant, and the pressure will vary according to the condition of the charges within the cupola. In the above case the horse power required varied almost directly from 8.5 up to 27, whereas the builders guaranteed it not to be over 10 to 27 horse power. It may be mentioned that in the efficiency calculations the temperature of the air delivered was carefully taken into account, so that the quantity of oxygen for the work required was actually delivered.

It is but natural that foundrymen, who use a blower ordinarily only for a few hours a day, will hesitate to spend the money for this equipment, even though the efficiency is excellent. However, more and more foundries are going into continuous melting operation, so that the blower will operate all day long. Here it is of great importance whether the blast of the cupola is obtained in an efficient or a wasteful manner.

* Presented before the American Foundrymen's Association, Chicago Convention.

A Dummy Plate for Loam moulds.

By "W. F."

Loam moulding offers less opportunities for dummy-plate methods than does green-sand moulding. Occasionally, however, jobs do turn up, which, owing to their shape and quantity required, lend themselves to this system of moulding. The sugar pan or chemical pan sectionally illustrated in Fig. 1 is one of the few castings that are made on this principle, and the following is a brief description of making one of these pans.

The spindle rest, Fig. 2, is laid on the bottom of the pit floor; the bottom plate is placed on it, care being taken to make the spindle rest secure, and a few

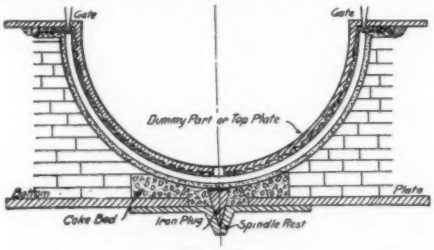


FIG. 1.

cokes to form a bed; and the mould is bricked up in the usual way. When the strickle spindle is removed from the mould an iron plug, the facsimile of the end of the spindle, is inserted in the spindle rest (see Fig. 1), and covered over with loam. When the casting is removed from the mould the bricked part of the mould should remain intact until the job is finished. The burnt loam is stripped from the bricks and cleaned out, the plug is removed from the hole in the spindle rest, the strickle spindle inserted, and the bottom part struck up again. This

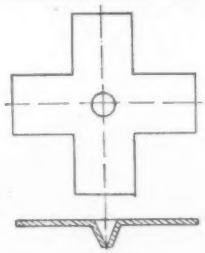


FIG. 2.

simple plug device will keep the hole in the rest clean. After the first casting has been made it is only necessary to hang a fire bucket in the mould and cover over with iron sheets to dry it.

In daubing up the top part of the mould or dummy-plate, Fig. 3, the rest is invariably fastened to the stove carriage until the job is finished. The strickle spindle is placed in the rest, the dummy plate is then well smeared over with loam and dried by hanging over a fire. When dry it is lowered over the spindle, the strickle fastened to the spindle, and struck up. After the first casting has been made it will not be necessary to warm the dummy plate, because the dummy is removed from the casting as soon as possible, and a coating of loam smeared over it whilst warm; this dries in a few moments; it is then ready to receive the final coat of loam.

Referring back to Fig. 2, in making the spindle rest the mould is made open sand, a brick or plate

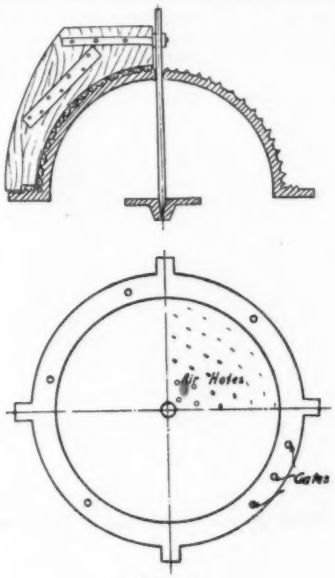


FIG. 3.

blacked for the spindle to stand on being placed in the bottom. The spindle is made of 2-in. round iron, the end turned to a taper point about 7 in. long; this should receive a coat of blacking or oil to facilitate its removal when the rest is cast. Pre-

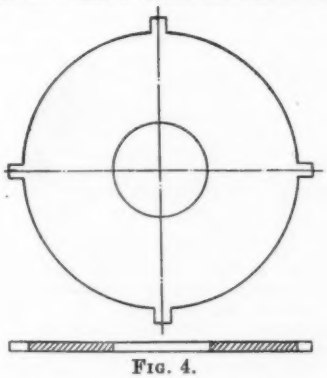


FIG. 4.

vious to casting, the spindle is adjusted with a plumb or level to ensure its being perpendicular. A rest made on this principle will not require to be bored out, as the hole will be true to the spindle; neither will it require a plank to steady the top of the spindle when striking the moulds up. The bottom

plate, Fig. 4, does not require any description, being only a plain, round plate with a hole in it.

Referring to Fig. 3, the dummy plate is made in a loam mould; it is well prodded; gate holes and vent holes are also cast in. It is, practically a facsimile of the casting to be made, with the addition of a flange and four trunnions for turning over and lifting the plate about.

In making the dummy plate, Fig. 5, the cope or top plate is built up with bricks about two-thirds of its height. A prodded plate with four loops cast in for bolting to the plate is placed on the top, and the whole struck up. When dry, four strong hooks, threaded at the end, are placed in the loops of the prodded plate, and passing through the holes in the top plate, are screwed up until taut. It can then be turned over in readiness for assembling.

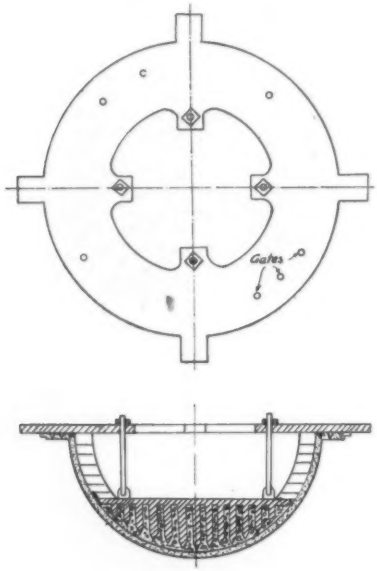


FIG. 5.

When the time required for bricking up a top part is taken into consideration, as illustrated in Fig. 5, in comparison to the time occupied in striking up a plate, it is obvious the dummy-plate system pays, if the number of castings justifies the expense of making a plate.

Influence of Changing the Composition of Malleable Castings.*

BY P. RODIGIN.

In order that a proper conception may be had of the influence of metal and alloy additions to malleable castings (black-heart), it is necessary to assume that in the annealing process the material is in a fluid or semi-fluid state (so far as the mobility of the molecules are concerned). The precipitation of graphite at the moment of set from liquid grey iron, thus finds its counterpart in the formation of temper carbon in the malleable casting. Similarly can one understand the relation of graphite to the other elements in cast iron as compared with the temper carbon in the malleable casting. So far as physical effects are concerned, these are comparable in a measure, as, for instance, the hardening effect of manganese, sulphur, etc., though the percentage prevalent are different.

I have instituted a number of tests on the effect of adding diverse elements to malleable cast iron, in order to study the resulting chemical and physical properties.

Manganese.—Adding this element promotes the separation of temper carbon in the annealing process. I do not subscribe to the opinion of Ledebur and other well-known experts who hold that manganese prevents graphite formation. Only in the case of large percentages is this the case. However, I have noticed that the strength of malleable castings suffers considerable with the higher manganese ranges, as graphite is separated out, and shrinkage cracks become more marked. Rapid cooling of the material after annealing results in a recombination of the temper carbon, and the fracture exhibits a silken white appearance. Manganese increases the fluidity of the metal.

Silicon.—Increasing this hastens the annealing process. The strength is reduced, but in not so great a measure as through high manganese. It also increases fluidity.

Aluminium hastens annealing and reduces strength. In large amounts it gives porous work, as deoxidation with formation of gases continues up to the moment of setting. It reduces the fluidity of the molten metal.

A rather interesting occurrence was noticed in connection with the addition of comparatively large percentages of aluminum, and that was the separation of graphite in sufficient quantity to give a grey fracture—thus confirming the observations of other experimenters. The peculiar situation, however, was that the annealed samples turned out to be pretty good malleable, the fracture being very black from the additional temper carbon formed as the result of the heat treatment given. The annealing was done in a remarkably rapid time, only a few hours being required.

Titanium.—This accelerates the annealing process.

Antimony and Tin.—Additions of these metals make the castings brittle, as well as damaging the fluidity.

Copper.—Retards the annealing process materially, and renders the metal less fluid.

Bismuth and Lead badly affect the fluidity, but otherwise have no effect on the time of annealing.

Sulphur and Phosphorus.—The following tests were made:—To the same molten metal, containing Si. 1.10, Mn. 0.46, P. 0.100, and S. 0.07, and when annealed giving 2.20 temper carbon (presumably by boring right through the casting and taking all the chips), there was added in one ladle some sulphur, and in another some phosphorus. Castings were then made from both and annealed under identical oven and heating conditions. The S. sample had the temper carbon drop to 1.4 after annealing, the sulphur being 0.23. The P. sample had 2.1 temper carbon, with the P. 0.19.

My observations indicate that as the sulphur rises annealing becomes more difficult (for black-heart), and when quite high the material will not anneal at all. Even when annealed, the fracture is not fine black and the castings are not strong. The castings are, moreover, difficult to pour, as the metal will not remain fluid long enough, and unless cooled very carefully after annealng any chilling action is liable to make the fracture white again. Sulphur is the dangerous element the founder has to contend with.

Phosphorus retards the annealing action, requiring more time as a consequence, and when in comparatively large amounts weakens the material.

* Presented before the American Foundrymen's Association, Chicago Convention.

Foundry Sands and their Treatment.

By Algernon Lewin Curtis, M.E.

(*Continued from page* 730.)

The Examination of Moulding Materials Before and After Heat Treatment—(*continued*).

Figs. 11, 12, 13, 14, and 15 represent the five different slide samples of the same material when photographed under the microscope. The photographs were taken from a 100-gramme sample of Lancashire red moulding sand in use in many foundries in that county. Fig. 11 represents a sample of that sand in its natural state; a 1-in. Watson objective = ×50 diameters was used, and an Abbe illuminator with top lens removed substituted for the polariser. A potgreen glass or light filter was also used in conjunction with an iris diaphragm, the latter half closed; the sample was mounted in cedar oil, and the exposure 20 seconds.

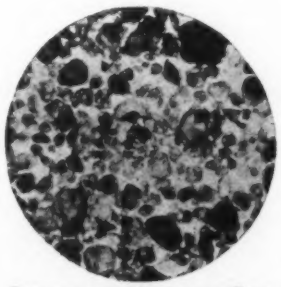


Fig. 11.—Lancashire Moulding Sand; Natural State. Mag. × 50 Diams.

Fig. 12 is a sample of the same sand, but only those particles photographed which were retained on a 50-mesh sieve. This slide was photographed in the same way as Fig. 11, the only difference being the mounting medium, in this case balsam in benzol replacing the cedar oil, and the power, which was ½-in. Watson objective = ×96 diameters.

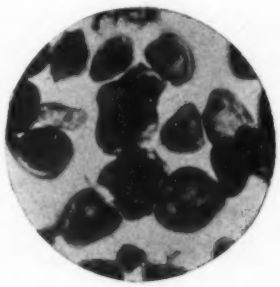


Fig. 12.—Lancashire Moulding Sand; Residue on 50 Sieve. Mag. × 96 Diams.

Fig. 13 represents the 3rd sample of the same sand, but the coarser particles were removed by sieving through a 50-mesh, and the finer particles also by being sieved through a 100 sieve. The material was mounted in balsam in benzol and taken by a ½-in. Watson objective = ×96 diameters. An Abbe illuminator with top lens intact was used in conjunction with an iris diaphragm, the latter three-quarters closed, and the exposure was two minutes.

Fig. 14 represents the fourth sample slide of the same sand, but only those particles mounted which were sieved through a 100-mesh sieve. The material was mounted in balsam in benzol and taken by a ½-in. Watson objective = ×96 diameters, an Abbe illuminator with top lens intact, in conjunction with an iris diaphragm, the latter nearly closed. The illuminator was lowered as far as possible to get detail, then the diaphragm nearly closed until the edges of the field began to darken. The exposure was 23 seconds.

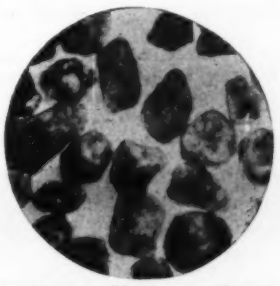


Fig. 13.—Lancashire Moulding Sand; Residue on 100 Sieve. Mag. × 96 Diams.

Fig. 15 represents the fifth sample of the same sand, only those particles being mounted which would pass through a 100-mesh sieve. These were then elutriated and filtered, only the lightest filtrate being mounted. This slide was taken in the same manner as Fig. 14, but the exposure was 22 instead of 23 seconds.

Having prepared and mounted a set of five different samples of a moulding material, which is necessary if an accurate examination is desired, the next step is to make test pieces or cores (as described in previous articles) for testing the refractory quality of the

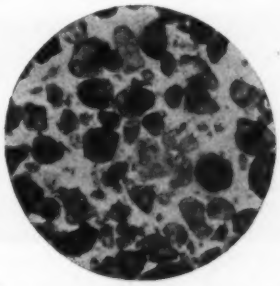


Fig. 14.—Lancashire Moulding Sand; Through 100 Sieve. Mag. × 96 Diams.

material. These are placed under the blow pipe, Seger cones, a Fèry absorption pyrometer, and a "Stereo" pyrometer being used to check temperature. The latter instrument, an invention of Mr.

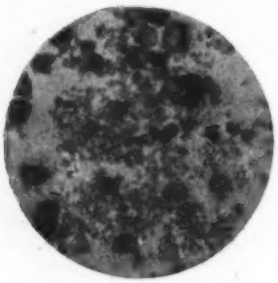


FIG. 15.—LANCASHIRE MOULDING SAND; CLAY SUBSTANCE. MAG. × 96 DIAMS.

H. L. Heathcote, B.Sc., of Coventry, and made by W. and J. George, Limited, Great Charles Street, Birmingham, has already been described in our columns. It can be used between temperatures of 550 deg. C. and 2,000 deg. C. By means of different

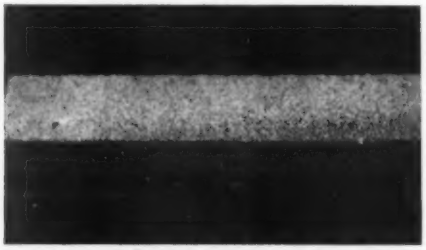


FIG. 17.—LANCASHIRE MOULDING SAND TEST-PIECE AT NORMAL TEMPERATURE.

pairs of cells filled with dye solution, ranges of temperatures in units of 50 deg. or 20 deg. C. can be recorded. This instrument is a valuable auxiliary to the Fèry absorption pyrometer, and both can be used together with very successful results, the one checking the other, so that a good mean average can always be obtained.

Since the publication of the previous articles the

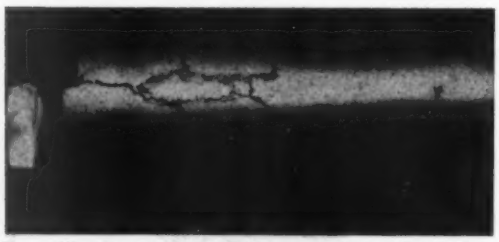


FIG. 18.—LANCASHIRE MOULDING SAND TEST-PIECE AT 1,200 DEG. C.

British Oxygen Company, Limited, have at the author's suggestion made a special blow-pipe for use in testing moulding sands and materials. This blow-pipe is fitted with very sensitive screw-down oxygen and coal-gas valves, which make the fine adjustment of flame now a comparatively easy matter. Fig. 16 shows the new style of blow-pipe.

Figs. 17 to 24 are full-size photographs of eight test pieces or cores with their respective Seger cones included, which with the exception of Fig. 17, have been exposed to high temperatures. It will be

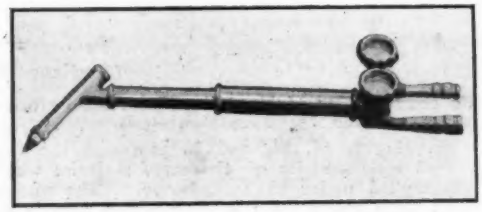


FIG. 16.—BLOW-PIPE FOR SAND TESTING.

noticed from these illustrations that the specimens from normal temperature to 1,500 deg. C., remain almost intact, while above 1,500 C., only the skin is shown. This exfoliation has been caused by excessive heat, making handling of specimens responsible for breakages during removal from blow-pipe to slide.

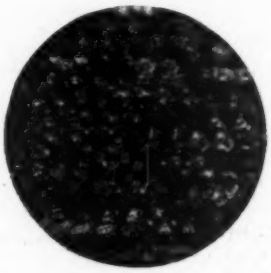


FIG. 17A.—MICROPHOTOGRAPH OF FIG. 17.

As these specimens are very fragile, great care should be exercised in handling them, and to enable such specimens to be better examined under the microscope they can be mounted with advantage on glass 3 in. by 1 in. slips in the following manner:—A flat plate of iron is placed on a tripod under a bunsen burner,

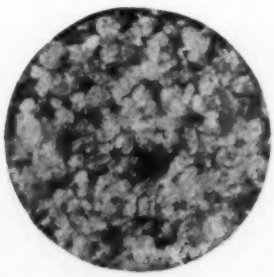


FIG. 18A.—MICROPHOTOGRAPH OF FIG. 18.

and a 3 in. by 1 in. glass slip put on the hot plate, then covered with dried Canada balsam crystals about $\frac{1}{16}$ in. thick. When the slide is warm and the balsam quite liquid, it is removed to a table to cool. After cooling the balsam will have set hard, and the test piece can be gently pushed from the tin slide upon which it rests after leaving the blowpipe on to the

slide previously coated with balsam. The slide with the test piece is then removed to the hot plate for the purpose of remelting the balsam, and directly that has become liquid the slide is removed to a cool place, and when cold the specimen will be stuck fast.

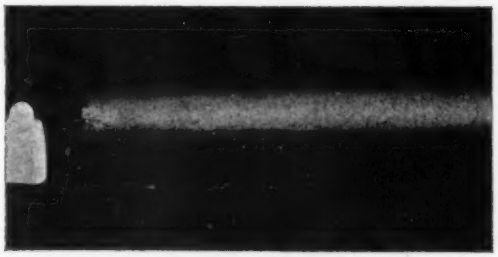


FIG. 19.—LANCASHIRE MOULDING SAND TEST-PIECE AT 1,300 DEG. C.

When exfoliation has taken place, and the bottom sand has become broken and loose, the skin should be removed, and the section be built up perfectly flat during mounting. The above photographs, Figs. 17 to 24 inclusive, represent test pieces or cores

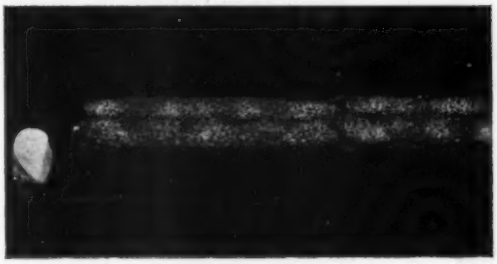


FIG. 20.—LANCASHIRE MOULDING SAND TEST-PIECE AT 1,400 DEG. C.

made from a 100-gramme sample of Lancashire red moulding sand, dried for an hour at 100 deg. C., rubbed in a mortar and mixed with 20 c.c. water to make it cohesive enough to work. With each illustration is shown the Seger cone used for the test.

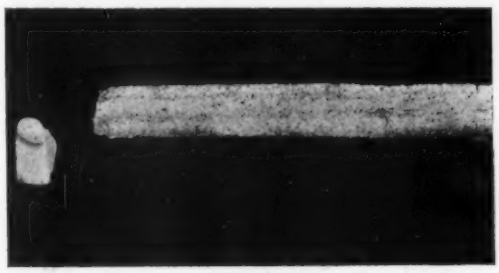


FIG. 21.—LANCASHIRE MOULDING SAND TEST-PIECE AT 1,500 DEG. C.

It is, of course, obvious that the nature of these specimens or test pieces necessitates them being kept in a horizontal position as much as possible; consequently, when examining them under the microscope the latter should be in a vertical position.

Having prepared and placed eight specimens of a moulding sand or material under the blow pipe at temperatures varying between 1,200 deg. C. and 1,700 deg. C., in order to make greater comparisons, and to get a better knowledge of the physical changes which have taken place due to the different ranges

FIG. 19A.—MICROPHOTOGRAPH OF FIG. 19.

of heat, it is necessary to place the specimens under the microscope and photograph them. Figs. 17A to 24A are photomicrographs of test-pieces Figs. 17 to 24 inclusive, magnified 50 times. Each specimen was travelled up and down the mechanical stage beneath

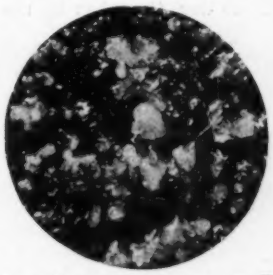


FIG. 20A.—MICROPHOTOGRAPH OF FIG. 20.

the microscope in order to obtain a mean average field of the state of material.

Fig. 17A represents a test piece of Lancashire red moulding sand at normal temperature taken by a 1-in. Watson objective = x 50 diameters; exposure five

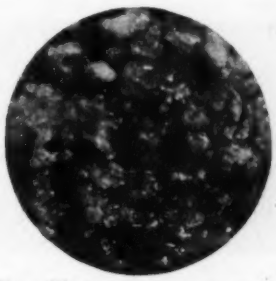


FIG. 21A.—MICROPHOTOGRAPH OF FIG. 21.

minutes. The horizontal position of the sand grains is caused by the action of the trowel when sleeking

Fig. 18A is the same sand, but exposed to a temperature of 1,200 deg. C., taken by the same objective; exposure four minutes. It will be noticed that

a bleaching action has taken place at this temperature.

Fig. 19A is the same sand, but exposed to a temperature of 1,300 deg. C., taken by the same objective; exposure four minutes. It will be noticed that the first sign of fusion (probably felspar) has taken place.

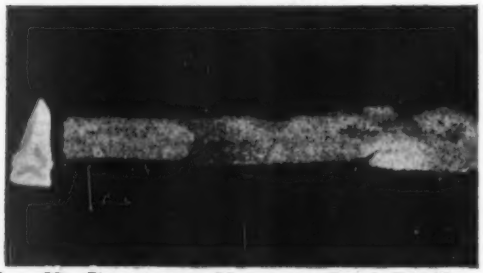


FIG. 22.—LANCASHIRE MOULDING SAND TEST-PIECE AT 1,600 DEG. C.

Fig. 20A is the same sand, but exposed to a temperature of 1,400 deg. C., taken by the same objective; exposure five minutes. The felspar has now begun to exercise a fluxing action on the quartz, as can be seen in the illustration.

Fig. 21A is the same sand, but exposed to a temperature of 1,500 deg. C., taken by the same objective; exposure four minutes. Parts of this material have begun to go to a glass.

FIG. 23.—LANCASHIRE MOULDING SAND TEST-PIECE AT 1,700 DEG. C.

Fig. 22A is the same sand, but exposed to a temperature of 1,600 deg. C., taken by the same objective; exposure four minutes. It will be seen that the sand has fused to a complete glass.

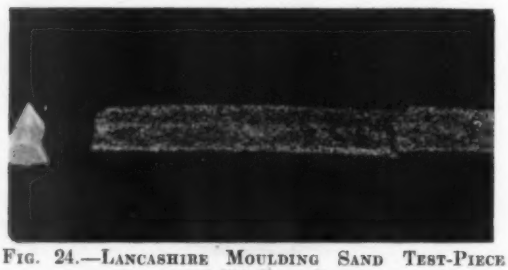


FIG. 24.—LANCASHIRE MOULDING SAND TEST-PIECE AT 1,800 DEG. C.

Fig. 23A is the same sand, but exposed to a temperature of 1,700 deg. C., taken by the same objective; exposure four minutes.

Fig. 24A is the same sand, but exposed to a temperature of 1,800 deg. C., taken by the same objective; exposure four minutes.

(To be continued.)

Aluminium in France.

The aluminium industry in France is carried on by five companies, viz., the Société Electrométallurgique Francaise, the Compagnie des Produits Chimiques d'Alais et de la Camargue, the Société des Forces Motrices et Usines de l'Arve, the Société des Produits Electrochimiques et Electrométallurgiques des Pyrénées, and the Société l'Electrochimie. These five companies have formed another company, L'Aluminium Francais, which acts not only as sales agent but is also intended to carry out research work on the applications of aluminium and to devote itself to a propaganda to encourage greater consumption of aluminium. This company also manufactures in its plants at Selzaete, Belgium, and Mennessis, France, considerable quantities of alumina, sulphate of aluminium, etc. It is now erecting at Arrean, in the Pyrenees, an aluminium factory and at Chambéry, in Savoy, a rolling mill for the manufacture of aluminium sheets, etc.

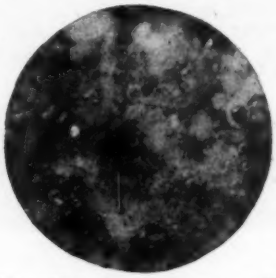


FIG. 22A.—MICROPHOTOGRAPH OF FIG. 22.

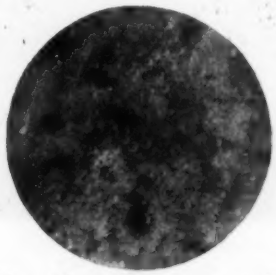


FIG. 23A.—MICROPHOTOGRAPH OF FIG. 23.

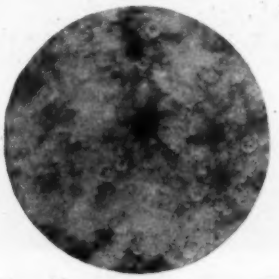


FIG. 24A.—MICROPHOTOGRAPH OF FIG. 24.

Reducing Pattern Costs.*

By D. Gordon, A.M.I.Mar.E.

When considering the many and varied methods adopted for reducing pattern costs, it should be borne in mind that their value is in every instance comparative, and depends—as an economic factor in the industrial world—not only upon initial costs, but also upon the relative costs of the work produced and the value thereof. False economic ideas as applied to some of these methods are all too prevalent, and show lack of appreciation of *ultimate* value, which is the only true way of apportioning a pattern's cost. A really typical example fully exemplifying one of these methods is the frequent use of a skeleton pattern with skeleton core-boxes and strickles, these being adopted when a large number of castings are required. The extra foundry labour involved, incidental to any form of skeleton and guide work, as compared with the uses of a "full" pattern, are ignored, yet, curiously enough, recognised, inasmuch as it is very common practice for the patternmaker

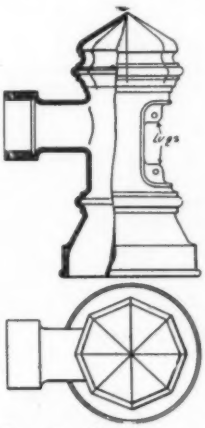


FIG. 1.—CAPPING HEAD-PIECE.

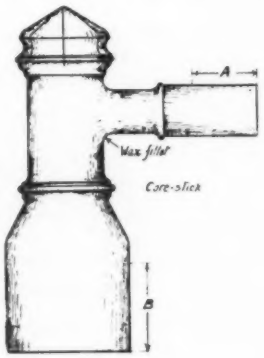


FIG. 2.—CORE STICK.

to request the moulder, or core-maker, in their respective jobs, to "make a bit up here" or "take a bit off there."

This practice must lead inevitably to the production of castings proportionally incorrect and very frequently dangerous. Further, such methods are wasteful of material, tending to produce unnecessarily heavy castings when such freedom with a mould or core is exercised, as a moulder, with a generosity for which he is notorious, ensures that so far as sectional thicknesses are concerned he at least will not be found lacking in liberality.

Yet again, some of the "brilliant" conceptions, as for example the conversion of a leaden pipe into a bend-pipe pattern, or the laying down of linoleum to make up a pattern to a given size, are, when considering the value of the oftentimes crude or fantastic castings with their excessive machining requirements, often found to work out at a very high cost, which latter is too often hidden under the term "convenience," a term hiding a multitude of both mental and physical laxities.

Owing to the scope of the pattern-makers' craft being so vast, and in its ramifications embracing much that is necessary for the production of work of either an artistic or scientific nature, it must be obvious that methods adopted by some of its branches are completely unknown to others. Taking some of the practices involved by one branch and applied to another where the practice is unknown, such applications being economically sound, must tend to the craft's development and its greater appreciation.

As an example, it is very rarely found that one very common method adopted for the production of some types of ornamental castings is exercised in the production of castings required for mechanical or electrical engineering work. This method, often referred to as the "core-stick" method, is advantageous in cases where the core-box costs are greatly in excess of the patterns' cost.

As an example, Fig. 1 gives the capping head-piece required for some types of weighing-machine standards. It will be obvious that, assuming the sectional metal thickness to be low—usually about $\frac{3}{16}$ in.—the core-box production involves great skill, accuracy and time, if made in the orthodox manner.

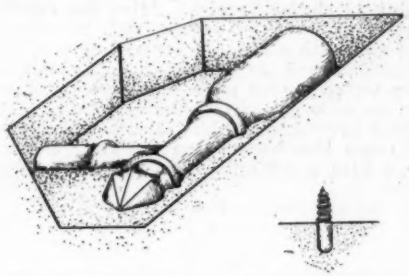


FIG. 3.—CORE-STICK BEDDED.

FIG. 5.—DOWEL PIN.

To make this core-box—the pattern being made in the ordinary conventional way—a duplicate of the core required is made up of wood, and may be either split centrally or formed solidly, Fig. 2, A and B lengths being the print lengths of the pattern. This duplicate wood core or "core-stick," as it is termed, is, if formed solidly, bedded into, and well beneath the surface of the foundry floor, or alternatively, a moulding box, a hole in the sand being previously formed to accommodate it. A sand joint is formed around this core-stick, the joint in every respect being similar to that required for the removal of a pattern from the sand, or a core from its box. This joint, away from the core-stick, need not be truly level, as any undulations formed are advantageous, as will be understood at a later stage. At the prints extermities, walls of sand are raised by means of a piece of wood fitting roughly over the prints which withstands and also restrains the sand rammed against it. The height of these walls should be in excess of the highest portion of the core-stick, such excess ultimately becoming the material core-box thickness. When the walls at the

* Paper presented before the London Branch of the British Foundrymen's Association October 31st, 1913.

print ends are formed, they are connected up by similar sand walls, as shown in Fig. 3. The core-stick is now painted over with any light oil, or may previously have been well rubbed over with dry plumbago; in either case the object is to form a parting between the bedded-in core-stick and plaster-of-Paris, which is poured within the space contained by the sand walls, covering the core-stick and filling up nearly level with the upper surfaces of the sand walls. Before the plaster has thoroughly set, a piece of wire mesh, slightly less in area than the space containing the plaster, is pressed into this latter and below its surface, a further addition of plaster being added if necessary to insure it being entirely covered. The object of this is to form a bond and give added strength to the plaster cast. When the plaster has thoroughly set—a fairly rapid

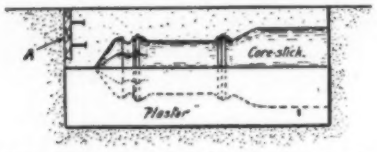


FIG. 4.—CORE-STICK READY FOR SECOND PLASTER CAST.

process—the surrounding sand walls are removed, and the cast withdrawn, containing, as a rule, the core-stick, and when this latter is taken out the impression left is obviously that required for one half of the desired core-box. The cast is now thoroughly cleansed, dried, and upon its joint surfaces is given a coating of shellac varnish. After the drying of this latter it is rubbed down with plumbago or painted over with a light oil for parting porposes.

When oil is used for this object, *i.e.*, parting two or more surfaces, care must be exercised to insure that no excess occurs, a fine film only being all that is required to accomplish this; otherwise if in excess, it will cause blow-holes of an unsightly character, combined with a difficulty in making a permanent "stopping up."

When the plaster core-box is dry, yet still in its "green" state, it is taken and placed into a space

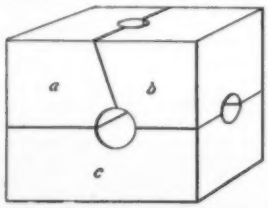


FIG. 6.—THREE-PARTED CORE-BOX.

cut in the mould, joint upwards, and sand walls raised around it in a manner similar to the first operation, and shown in Fig. 4. The core-stick is now returned to its former position, its upper surfaces being plumbagoed or oiled. Plaster is again poured over it and within this second made-up space, the plaster before setting being strengthened up as mentioned in the previous instance. When it has set, both plaster half boxes are removed (the last cast-up plaster obviously forming the remaining half-box), both cleansed and given two coats of a strong body varnish, in every respect similar to that adopted for a box in wood, upon the surfaces which will come into contact with the sand core. Although still in its "green" state, the box is ready for use. If the undulations formed upon the sand joints surrounding the core-stick are not sufficient to define and keep into position the respective half-boxes, further definition may be obtained by bedding into the sand ordinary plug dowels, as shown in Fig. 5, the plaster forming around the helices of this latter retaining it in position. Alternatively, a hole cut upon the first made-up sand joint surface will obviously make a projection which in its turn will form a socket to receive it in the half with which it comes into contact.

When it is necessary to further sub-divide the core-box, the joints required are formed as in the example given by raising sand walls the faces of which become the partings of the divisions. As an example, Fig. 6 is one view of a three-parted box *a*, *b* and *c* respectively. For making the joint between the portions *a* and *b* the portion *c* after being cast is placed into the mould as shown in Fig. 7, and the core-stick is placed into this latter and at its required angular joint, sand walls are made up as shown. Three additional walls are formed enclosing the space *b*, which, when filled with plaster, makes the equivalent of the part *b*, Fig. 6. After this has set, the sand X, Fig. 7, is removed and the surface of *b* and also *c* is cleaned and oiled, without removal if possible, the part *a* then being cast. Dowels may be formed, as previously explained, for defining the position of the various joints.

Patterns for Awkward Bends.

There is another class of work, including awkward pipe curves and bends, and numerous similar cast-

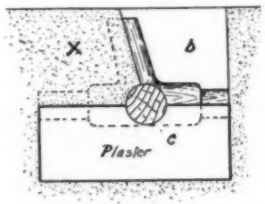


FIG. 7.—MAKING JOINTS OF THREE-PARTED CORE-BOX.

ings in which the pattern costs are usually disproportionately high. Castings which are intrinsically worth only a few coppers often, as regards their initial cost, involve expenditure which is comparatively heavy and excessive, owing to the cost of the pattern and core-boxes, which are essential and necessary for their production. As the cost of any type of casting is chiefly relative to its pattern charges, any means or process whereby these charges may be reduced is to be considered from this basis, time obviously being judged from the same base.

The process here explained for reducing some of these charges may be applied to a very considerable extent; but is more especially applicable to small detail patterns of an intricate nature or of abnormal form and requiring quick, accurate production. As the patterns and core-boxes produced are formed in plaster-of-Paris, with a plastic material or a modelling clay and moulding sand as mediums, it does not follow that any special qualifications are necessary, as the work involved is well within the scope and capabilities of the average pattern-maker and also the moulder, if he has a slight knowledge of the uses of a few wood-working tools.

Fig. 8 illustrates in elevation, plan and side view, a small bend-pipe connection of a more or less abnormal shape, this being taken as an example showing the possibilities of the methods here explained, which methods can be applied to a

very considerable extent. A length of wire, of a suitable gauge, is first bent to the shape and also the required lengths of the centre line of the connection (shown dotted). This wire is allowed to project slightly more than is essential at those positions which would be occupied by prints in the usual type of pattern for the same job. The excess lengths, which are in excess of the prints' extremities, are desirable to allow the formed wire to be held firmly when gripped in a vice without interfering with the required pattern and print sizes. Upon this wire, Plastacine or modelling clay is placed, after having been previously formed to the required section of the core.

To obtain the correct plastic-material section it would, of course, be a very dubious proceeding to form it by hand modelling; to ensure correctness and reduce the labour and time involved to a minimum, it is formed mechanically in half-sections by means of a "section former." These "formers" are is every respect similar to half core-boxes in wood, but being formed in the straight, they are easily and quickly made, and may vary in section from square to circular or eliptical. The section surface of the former is well rubbed down with dry plumbago or oiled with any light machine oil, this being to prevent any clinging between the wood of the section former and the plastic material, which is bedded into the section former and struck level to the surface with a straight-edge, forming a straight half core in the material used. Centrally, a length of wire of the same gauge as used for the shaped-up wire centre line is bedded halfway into the plastic material, and when removed this wire impression (A, Fig. 9) becomes the guide for placing the formed material upon the bent-up or formed centre wire (x Fig. 10).

Sufficient pieces for forming the complete core section and for the required length are thus made in the former, the removal of the various plastic material sections intact being done by lifting one end of the material and drawing it along, but away from the section former, as shown in Fig. 9, where B is the former for the example taken. The half-plastic sections are then joined together and around the shaped wire centre, the line A (Fig. 9), giving the guide line for the position of the sections in relation to the wire. Where the half-sections abut, the finger is drawn, with slight pressure only, along the joint, sufficient compactness being thus given for the adhesion of the parts. If owing to imperfect jointing any portions require making up, this is easily remedied by means of a template, Fig. 11, which latter is cut to the core section as at o, and its edge bevelled. In using the template its action is similar to a scraper, and for this reason it should have no sharp corners, as it is necessary to work it over the core surfaces quite freely and quickly, removing any superfluous material which it may have been found necessary to add when making up an imperfect part.

After the core has been correctly formed, its surfaces are painted over with a blackwash consisting of plumbago and water, this being required to prevent cohesion between the core and the mould sand with which it eventually comes into contact. When the plumbago surfaces are quite dry, the core is taken and bedded into sand (C, Fig. 12), which latter may be contained in a moulding box or in the foundry floor; but in either case the most elevated portions of the core must be well beneath the floor surfaces, or, alternatively, the upper edges of the box containing the mould. A joint is formed around the core the same as would be found necessary for its removal if it were a pattern being moulded or the parting joint of a core-box for a sand core's removal. Apart from the desirability of seeing that the parting is equal, or otherwise, for removal purposes, any depressions or undulations formed on the surrounding joint surfaces are rather an advantage, as they tend to act as a register for defining position; and with reference to this latter necessity, a dip, as shown at A, Fig. 12, is made, which dip forms the plug dowels for the completed box.

At convenient distances away from the core, walls of sand are raised, this being done by placing a piece of wood upon its edge on the formed mould joint and ramming sand against its sides. The height of these walls should be in excess above the highest portion of the core and this excess will be the amount of the core-box material thickness at this position. These walls entirely surround the core and, where occasion requires, at the prints' extremities in the example given, the wall B (Fig. 12) is formed up at the prints' ends. Into this mould (Fig. 12), and entirely covering the plastic-material core, plaster-of-

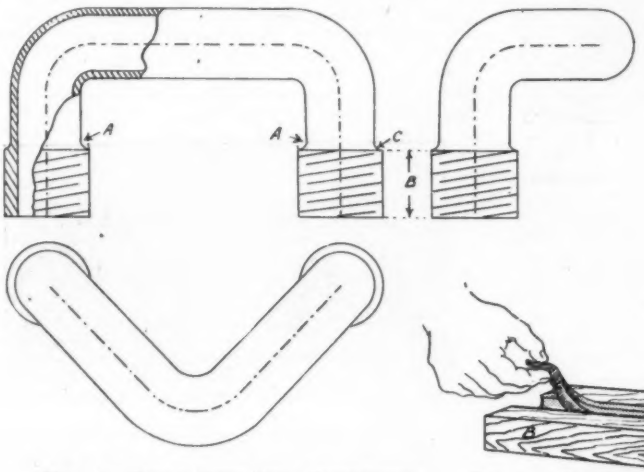


FIG. 8.—SMALL BEND-PIPE CONNECTION.

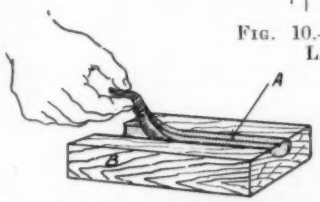


FIG. 9.—SECTION FORMER FOR PLASTIC MATERIAL.

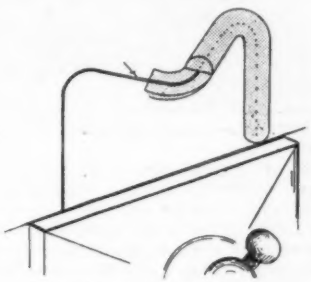


FIG. 10.—PLASTIC MATERIAL BEING LAID ON CORE WIRE.

FIG. 11.—TEMPLATE.

Paris is poured, this being made to the consistency of cream, and screened by hand before pouring to remove any lumps formed, which lumps are more or less incidental to the making of plaster-of-Paris. Before the plaster has quite set (a fairly rapid process), a piece of wire-mesh, in size slightly less in area than the covering plaster within the mould walls, is bedded in below the surface and covered over with additional plaster, as in the core-stick

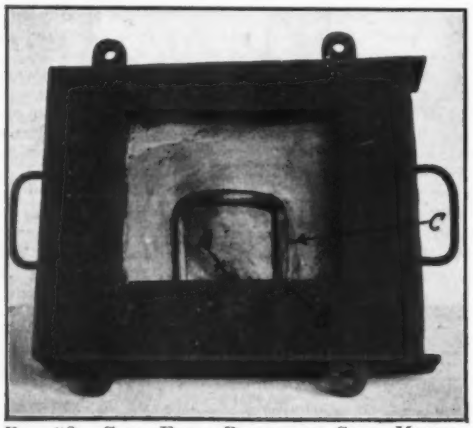


FIG. 12.—CORE FORM BEDDED IN SAND MOULD.

process previously described. In cases where the walls are of excessive height it is advisable to give further strength to the box by placing at various positions lengths of wire rod. These rods are placed across, angular or straight as required, being let into the sand walls sufficiently to carry them during the period of casting up in the plaster.

After the "cast" has thoroughly set, the surrounding sand is removed and the plaster cast lifted

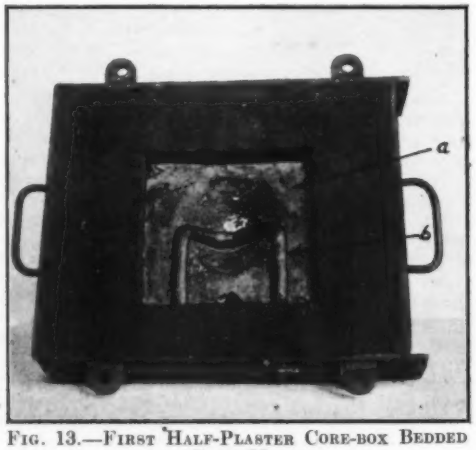


FIG. 13.—FIRST HALF-PLASTER CORE-BOX BEDDED IN SAND MOULD.

out, which latter as now formed is one-half of the core-box (*b*, Fig. 14). Assuming that the joint has been correctly formed, it will be found that the plastic core can be removed intact, but if, on the contrary, this is not so, then it will be obvious that a sand core will fracture when removed under the same conditions, and it is necessary at this stage to rectify those parts which create such fractures. The "cast" is then thoroughly cleaned with water and dried, after which its surfaces are coated over with shellac varnish, and when this latter has dried the half core-box is placed into an empty moulding box or a prepared space well beneath the foundry floor surface. As done in the previous instance, sand walls are raised, the edges of the plaster box being the guide for their positions and the height being in excess—for the same reasons as for the first-formed half-box—of the highest portion of the Plastacine core, which has been returned to its former position in the plaster half core-box (*b*, Fig. 13). When the mould walls are finished, the surface of the plaster box is given a coat of any light oil—olive oil for preference, as it is less likely to create oil bubbles, which in turn form blow-holes—this being upon its surfaces with a camel-hair brush, care being taken that no excess oil is allowed to remain, as this excess will form large unsightly holes or channels. The reason for oiling this plaster surface is to prevent adhesion between the already formed half core-box and the liquid plaster-of-Paris, which is now poured upon its surface and within the last-formed mould walls (Fig. 13). In its result it forms the other half of the required core-box (*a*, Fig. 14), and being so, it will be quite clear why undulations on the joint surfaces are an advantage for defining the relative positions of the two halves. It will be found that the halves part quite easily after the plaster has "set," owing to the oil, and that

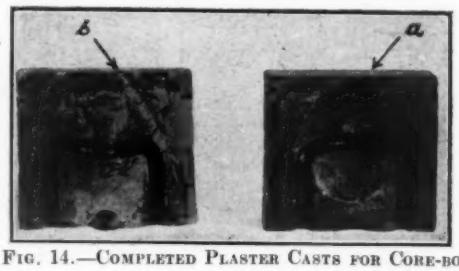


FIG. 14.—COMPLETED PLASTER CASTS FOR CORE-BOX

the core also retains its form in every particular. After the last-formed half-box has been cleaned it is varnished, and when dry both halves at those positions which come into contact with the sand for forming the core are given a coat of body varnish, which latter fills the pores of the plaster and better withstands the searching action of moisture. The box is now ready for use and although still in its "green" state any cores formed from it will be found to be equally as satisfactory as those made in the conventional wood core-box.

To form the pattern, the plastic core that has been previously used in the making of the core-box is now used as a base upon which to build. This is done by placing upon the core surfaces thicknesses of plastic material equal in thickness to the metal thickness required around the core. To make these thickness pieces or strips, a flat piece of board is used, having attached on one of its surfaces two wood strips the thickness of the metal desired, their distance apart being such that the formed strip when removed will envelope the core when it is wrapped around this latter. For the example given, Fig. 15 shows the board with strips attached, A being the metal thickness and the distance apart of the strips S S at X being the circumference of the pipe connection. It will be noted that one strip of wood at C is chamfered off, thus allowing for the jointing together of the plastic-material thickness strips

where they come into contact, one edge with another, thus saving undue modelling of the joint. The jointing together of the plastic edges is done in a similar manner to that applied for jointing the core.

Between these strips S—S the plastic material is kneaded in slightly above the strips' thickness, and is brought to the correct thickness by a straight edge *b* (Fig. 15), drawn along the upper surfaces of the strips, removing all surplus material. The length of these strips is not important, but obviously the longer that they can be conveniently worked upon the core surface the less is the labour involved in jointing the various thicknesses together. It will be readily understood that it is only necessary to place the plastic strips around the core at

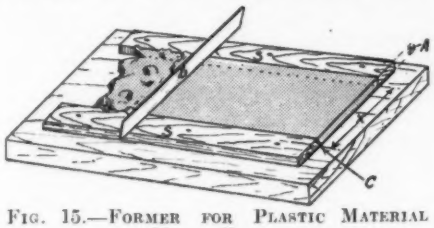


FIG. 15.—FORMER FOR PLASTIC MATERIAL FOR METAL THICKNESS.

those portions which define the pattern as distinct from the pattern prints, which latter are formed by the core and shown at A, Fig. 16.

The extra thickness required for the screw portion of the connection (A, A, Fig. 8), is made up by placing additional strips of the correct width (B, Fig. 8) around and over the metal thickness, pieces being made to run one into the other by the fillet C (Fig. 8), which latter can be formed separately by means of a V-board, as in Fig. 17, or worked from the strip last laid on. The separate fillet wrapped around and into position will be found to be the easier and quicker method.

After the pattern form is thus made, it is taken and moulded, the sand being packed firmly yet lightly against its surfaces. The first sand ramming

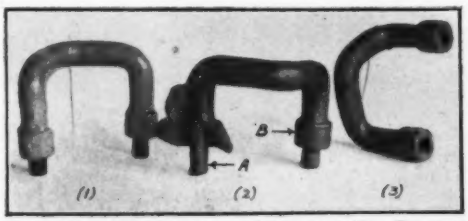


FIG. 16.—(1) PLASTER PATTERN; (2) PLASTIC PATTERN FORM; (3) COMPLETED CASTING.

should be done as far as possible with the fingers; but with each additional course of sand firmer ramming may be indulged in. The chief point to remember with reference to the ramming up of the plastic pattern is that the mould impression formed will be sufficiently compact to carry plaster-of-Paris, and in no sense is required to withstand any disturbing actions as are generated in a mould for containing metal. The plastic pattern is parted in the mould, for removal purposes, in a similar manner to that already described for the moulding up of the plastic core, but in this instance the mould joints abut against each other. When the pattern is withdrawn large gates with large feeding heads attached are made, and the runners also are very deeply cut so that the poured-in plaster may have easy access into the mould. It is also necessary for plaster-of-Paris casting to have many risers attached which, with the feeding gate, are kept open until a solid body is obtained. If these precautions are not taken it will be found that large blowholes are formed, as the plaster has not sufficient weight or force to expel the air collected within the mould unless every facility is given for it to escape.

To give additional strength to the plaster pattern a strong wire fixed into the mould through the prints

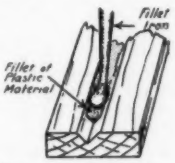


FIG. 17.—FORMER FOR FILLET.

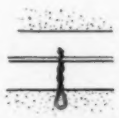


FIG. 18.—WIRE REINFORCEMENT.

extremities, and running centrally throughout the job, will be found to be a great advantage. As rapping of the plaster pattern is liable to create fracture, this can be obviated considerably by having wire projections attached to, or formed from, the central wire. These wire projections pierce into the

FIG. 19.—STRIP FOR STRENGTHENING PLASTER CASTS.

mould previous to casting the pattern (Fig. 18) and after this latter process the wire projecting from the pattern surface can be utilised to take the rapping blows, the forces of which owing to the projecting wires being attached to the main central wire, are transmitted to the whole pattern. It will be obvious

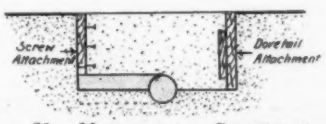


FIG. 20.—METHODS OF STRENGTHENING PLASTER CASTS.

that the amount of wire which pierces the mould in the first instance will be the amount projecting from the pattern surface when cast up and, apart from rapping, will also act as lifters for the pattern's removal from the mould.

When the plaster-of-Paris pattern is taken from the mould it is cleaned, the runners, etc., cut off,

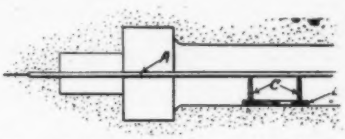


FIG. 21.—RAPPING PLATE IN MOULD READY TO RECEIVE PLASTER.

and, if necessary, made lineable by ordinary woodcutting tools. It is then sandpapered and varnished, the same as a conventional pattern of wood. In Fig. 16, (1) shows the completed pattern; (2) displays the construction of the first or plastic pattern, and (3) shows the final casting in metal.

In some cases it may be necessary to further subdivide the core-box, or pattern, into three or more pieces to allow accessibility for removal of either the core or the pattern from the sand. In both cases the joints required for separating purposes are formed in a similar manner to the examples given, *i.e.*, by raising up sand walls, the faces of which become the partings of the divisions. This procedure is the same as explained for the core-stick method, as shown in Fig. 6.

In conclusion, if many cores are required, yet not a sufficient number to warrant the casting up of a metal core-box—the plaster-of-Paris core-box acting as the pattern—added durability may be given to the box by attaching to its sides pieces of wood, which latter will take the force of the rapping blows—the jar created being, of course, taken up by the whole box—and tend, by its greater resiliency, to prevent fractures. To attach these wood pieces to the plaster, one method is to form a double dovetail of wood, as shown in Fig. 19. The side strip is then placed against one of the mould walls, and within the space to be occupied by the plaster, which latter, when poured in, attaches itself around the dovetail, forming a bond between the plaster and wood.

In preference to the dovetail method, screws staggered with the heads well projecting from the side-strip surface, may be used, and in Fig. 20 two side pieces of the alternative methods given are shown placed in position previous to casting up and for attaching to the core-box portion.

Owing to the possibility of a plaster pattern fracturing during rapping for its release from the sand, and also, in some cases, presenting difficulties for lifting, rapping and lifting plates may be cast up with the plaster pattern, obviating these disadvantages. In Fig. 21 a mould section is given ready to receive the plaster, A being the centre strengthening wire, B the combined rapping and lifting plate, with screws C placed into the holes common to these plates for attaching purposes. Sand is pressed into the lifting and rapping holes, and obviously, when the pattern is cast up, the plaster will surround the plate and its screws, thus forming a strong, durable fixture to the pattern.

Discussion.

The CHAIRMAN (Mr. J. Ellis), in opening the discussion, suggested that the latter process described by Mr. Gordon was more suitable for "one-off" jobs. He suggested that the pattern shown would be difficult to get out of the sand when made in one piece. He also thought that pins should have been inserted in the core-box to ensure proper alignment.

MR A. BARTLETT desired to know what was the average life of the patterns in plaster shown. He used plaster to make master core-boxes from which metal boxes were made for the core maker, for use in oil-sand core work.

MR. J. W. WORRALL said he considered the process employing a plastic material and plaster to be very useful. As to the life of the patterns, this would not be a serious matter as the cost of producing a new set was comparatively so small, 50 costing no more than one wood pattern and core-box. In forming the plastic-material pattern, was there any trouble with it distorting during the making of the joint? Also, had Mr. Gordon any data regarding the contraction or expansion of plaster during setting?

MR. WILLIS, referring to the first process described, said he would not ask for the core-stick and print shown. He would prefer to mould in plaster the full pattern and then cut down to gauge while still rather soft, so as to get the core form, which could be laid in the mould to see whether it fitted correctly. This, he thought, was very much quicker and simpler than cutting out the core-stick in wood. With regard to plaster core-boxes, he had made them for various work, but had found that they developed cracks after using two or three times, while after using half-a-dozen times the ends had broken off, even when wires were used as reinforcement. He approved of plaster-of-Paris patterns, but only as means of making metal patterns. But even in this there was difficulty in providing for contraction, particularly in making bends. In fact, plaster pattern work was not at all easy with bent work. For the bent pipe shown he suggested a cheaper result could be got by bending up a piece of lead pipe. With plaster there would be a tendency to get irregular thicknesses round the bends. A more even result would be got by cutting down to gauge as at first suggested.

MR. SLATER thought the pattern shown could be made in plaster with rapping holes and all cast in, which would save the rough usage mentioned by previous speakers. He took it that Mr. Gordon meant the method as an emergency job; but if it was required for a regular job, metal patterns and boxes could be cast from the plaster. As regards contraction, there was very little contraction experienced with plaster-of-Paris during setting. He had found plumbago and paraffin a suitable parting for these plaster moulds. As to why plaster was harder when allowed to set uncovered, he considered this to be due to the steam generated during the setting being allowed to escape; when the plaster was covered the steam was retained, and the plaster was found to be softer on the surface than when uncovered.

MR. A. BARBER remarked that whatever criticisms were offered, the fact remained that the lecturer had placed before them a pattern and core-box which was made by a boy in less than six hours, whereas it has been admitted by one patternmaker present that it would take a boy nearly a week to make the same in wood. He (the speaker) could mould and cast in metal in a very short time another pattern and core-box from the plaster if that latter was not considered strong enough for much use. The economy was obvious. As to the variations in thickness likely to be experienced, the rapping which a boy would give a wood pattern would give greater variations.

MR. T. W. AITKEN asked whether Mr. Gordon knew of any process of hardening Plastacine. There were many patterns required which were extremely light. Was it possible to make them in Plastacine and harden it for moulding. As to the casting of the patterns, etc., in metal, where many bends were involved, there would be great difficulty in getting the corners correct on account of the contraction. The cores after drying would not fit properly.

For assisting the hardening of plaster other speakers suggested the use of both hot water and thin glue-water in mixing.

MR. GORDON, in reply, said that, in regard to durability of plaster patterns, the insertion of straight wires as reinforcement was not nearly so satisfactory as wire mesh, which had a much better hold on the plaster owing to its formation. Rapping plates could easily be included in the pattern by placing them suitably in the mould before casting up with plaster. As to the contraction of plaster, this was very little, the cast coming out practically of normal size. The suggestion by the chairman that pins should be inserted in the core-box could very easily be met by merely sticking a finger into the first-half plaster before it was set; on pouring the following cast of plaster the pin would then be formed in the hole made. Mr. Willis, criticising the core-stick method, had objected to the labour of

making the core-stick, and preferred to cut down a plaster cast to gauge. His (the speaker's) method was simpler, since the moulded flats could be cut down in the lathe in much less time and with greater accuracy than plaster could be cut. The contraction round the bends of a pipe made by the second process described, which had been discussed by some of the members, would occur with a wood core-box, as it probably resulted from the drying of the core. If more than 12 castings were wanted from the same pattern it was only necessary to cast metal patterns and core-boxes from the plaster, when any number could be moulded. It was not a difficult matter to make the necessary allowances for contraction. A question had been put regarding the use of Portland cement mixed with the plaster; this, however, resulted in the plaster cast cracking badly during setting. A simple way of parting plaster patterns at any point was to insert lead-foil or tin-foil at the desired point, when a clean parting would be found after casting up in plaster.

At the conclusion the lecturer was accorded a hearty vote of thanks for his address.

Metallurgical Nomenclature.

The subject of the "Nomenclature of Alloys," was discussed on Tuesday evening at a meeting of the Birmingham Section of the Institute of Metals. Professor T. Turner (Chairman of the Section) presided, and a number of eminent metallurgists, some of them visitors for the occasion, took part in the meeting.

Dr. Rosenhain said that although he was chairman of the Committee appointed by the Institute of Metals to investigate the question, the views he would express must be taken as individual and unofficial. The present condition of metallurgical nomenclature was a state of chaos, and in this country and in America movements had been commenced to provide a more rational system. The trouble arose when a metal was called by some name intended to describe its nature, such as manganese-bronze, brass-bronze, or aluminium-bronze, which were actually misleading terms, because they were used in so many different senses. There was no desire to force a scientific system on an unwilling trade, but what they wanted was to apply ordinary practical common-sense methods and to evolve a rational system by which a person could know what he was selling or buying. In some cases the use of such ambiguous terms as "manganese-bronze" had lead to litigation. Elaborate scientific terms should be avoided, but English names commonly used in the foundry and workshop should have a definite and clear meaning. A great deal could be done by deciding in what order alloys should be mentioned so as to suggest the percentage of composition.

Having given some illustrations of this, Dr. Rosenhain said that it was possible to do more than call copper-zinc alloys by that name. They could be called "copper-zinc" or "zinc-copper," implying that the metal named first was present in the larger proportion. "Brass," might stand as the term expressing copper-zinc, and as meaning nothing less than 50 per cent. of copper. Where there were more than three elements they could say "compound brass," or might introduce the term "co," which would mean a complex brass. In the bronzes "copper-tin" would serve as a fairly wide definition of bronze. "Aluminium-bronze," in its present usage would be excluded, because the term as used in future would mean a tin-copper alloy containing aluminium. German silver was a very vague term covering a multitude of sins. That alloy might be represented by the term "nickel-zinc-copper" or "nickel-brass."

Mr. G. A. Boeddicker thought that the introduction of the term "nickel-brass" would spoil the sale of German silver altogether. It was understood that the term "German silver" indicated in a general way that the metal looked like silver.

Mr. Spittle said that almost all brasses in Birmingham had special names which defined them to the average man in the trade. For instance, brazing brass was well understood as containing at least 66 per cent. of copper, but many people asked for bronze who really wanted gilding metal.

Mr. H. Rogers thought they should retain class names as far as possible, especially where they had become familiar and a departure from them would not be responded to. He would, however, suppress such names as gunmetal, German silver, aluminium-bronze, manganese-bronze, and generally eliminate the word bronze from all copper alloys containing less than 2 per cent. of tin. He would suppress most of the local names for copper-zinc alloys, but trade names or fancy names might be retained, provided they carried with them a fundamental class name descriptive of their composition. All purely copper-zinc alloys should bear the generic name brass. For gunmetal he would substitute the class name bronze, representing all alloys of over 2 per cent. of tin. Manganese-bronzes containing alloys added to give great strength, should be called "high-tensile brass."

Dr. Brownsdown suggested that nomenclature could easily be made intelligible by the free use of numerals indicating composition, as in chemistry.

Dr. Rosenhain, replying, said that there was no idea of offending customers, and it might take a generation to carry out a satisfactory change. Nor did they propose to force the adoption of scientific terms. He thought the numerical system would prove complicated and elaborate.

Safety in Iron and Steel Works.

Some interesting observations were made at the recent Safety Congress in New York, held simultaneously with the meeting of the Association of Iron and Steel Electrical Engineers, by Mr. L. H. Burnett, assistant to the president, Carnegie Steel Company. Among other things, he pointed out that proper lighting played a most important part in safety work and that in this respect wonderful progress had been made. Neat and clean surroundings also had an undoubted influence on the part of the individual. If he was required to work amid scenes of disorder, if the floor and yards were littered with refuse and loose material, he would become careless and slovenly in his habits and be much more liable to personal injury. It had been found that the installation of grass plots and flower beds at suitable points throughout works had the effect of stimulating the men to greater efforts in keeping the entire plant clean and neat. The Carnegie Steel Company was now installing at its several plants about 100 bulletin boards, uniform in design and construction, to be devoted solely to the display of articles and photographs pertaining to accidents and safety. Mr. Burnett expressed it as his opinion that the most promising method of preventing accidents was the system of bonuses to foremen and others in direct charge of operations, which has been adopted as an experiment by the National Tube Company. The greatest improvement, however, must come from the reduction of negligence on the part of the workmen. For several years the Illinois Steel Company made a careful classification of all accidents, with the following average results:—Accidents due to trade risks, 23 per cent.; to negligence of the company, 6 per cent.; and to negligence of workmen, 71 per cent.

Cast-Iron Road Wheels for Commercial Motors.

By Owen Linley.

In suggesting the use of cast iron for road wheels for commercial vehicles the writer is well aware it would be a new departure, but has had experience of this subject practically ever since these vehicles ran in this country, and does not think it impracticable. At present the wheels are of wood or cast steel; the former are the most reliable, but they are costly, heavy, clumsy in appearance and in some hot and dry climates, especially where water is scarce, it is impossible to use them on account of the shrinkage. The wheels of cast steel are lighter, cheaper and much neater looking, but they have been very unreliable, and are even so now to a considerable extent, although their design is better understood. Only recently a case came under the writer's notice of four vans being supplied to a firm, and there were failures of the wheels on every van. It will probably be of assistance towards the designing of cast-iron wheels to here describe how those of cast steel fail. Steel castings are subject to deterioration owing to the fatigue of the metal, through the vibration to which the wheels are naturally much exposed, especially in certain districts. Neither the amount of the weight carried nor the torque of the engine seem to have any effect on these wheels, but they break up through minute cracks starting at the edges of the arms and sooner or later extending right across. In fact, it has been said that many of these wheels are practically broken before they have ever been put on the road. Of course, the tenacity of cast iron is only about a third that of a steel casting, but it does not at all follow that a cast-iron wheel need be three times as heavy as the latter.

A cast-steel wheel would be practically unbreakable as far as any shocks that it might have to withstand, but it has to be much heavier than would be otherwise necessary, owing to its readiness to develope the above-mentioned fractures. Cast-iron wheels are used on trams, and a full-sized double-decked car with its complete complement of passengers throws a great stress on the wheels when taking points, and yet failures of the wheels are comparatively unknown. If a cast-iron wheel broke at all it would probably be on a greasy road, as these vehicles are apt to "skid" on the back wheels, one of which would be thus forced against the kerb, which in a town is of stone, and would give a certain amount of shock. It is very improbable that anything else would break a cast-iron wheel. Charging a kerb through bad steering, as at cross roads, where it would meet it at a right angle would throw a heavy stress on the front wheel, but it would not be one that would fracture cast iron, as the rubber tyre would act as a buffer.

Figures 1, 2, 3 and 4 show two views each of a typical front and back wheel of a motor van, and much the same practice applies to the wheels of an omnibus. The figures are dimensioned so that it will be easy to form some idea of their substance. It will be seen that the rubber tyres are vulcanised on to a continuous mild-steel band ½ in. thick which has dovetailed grooves turned on its outer surface, so as to form a better hold for the rubber. The inner surface of the band is turned, as is also the tread of the wheel, which should be so much larger in diameter that a pressure of 8 tons, applied by a hydraulic press is required to force it into the band. On the back wheels two of these bands are used side by side. No method seems to be of any use in keeping the band in its place on the wheel other than forcing it on as described, and this is a considerable point in favour of a cast-iron wheel, as these bands have great lateral stiffness, and would distribute to several of the arms any shock that the side of the wheel would meet at one point.

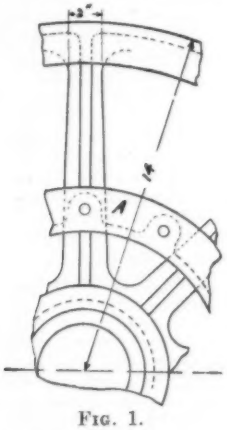


Fig. 1.

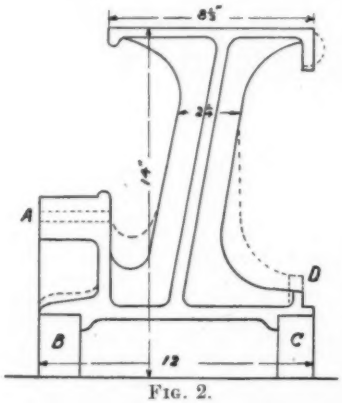


Fig. 2.

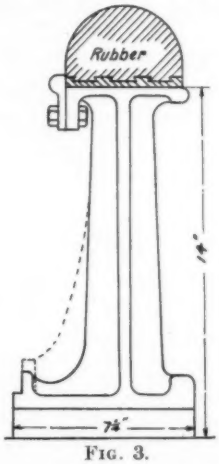


Fig. 3.

It will be seen that in Fig. 3 the wheel is provided with a mild-steel ring that has a beaded edge so as to protect the nuts and is bolted to a flange on the rim. At one time these wheels were made with a shallow flange on the outside and opposite the ring so that the band of the tyre was held between them. It has been found that this is not required, but for some reason that is not clear, certain makers still retain the rings. These cost about 6s. each, and then there are the bolts and the drilling. In the case of a cast-iron wheel, it would be better to dispense with this ring and throw out a projection as in Fig. 2, where it is shown by the dotted line, and the flange

could also be thickened somewhat without adding to the weight if the ring was left out. There should be a projection here on the outside of the wheels, as it is a great protection to the tyres.

The following are some points connected with the existing wheels. In Fig. 2 the ring A has the sprocket wheel bolted to it. B and C are bored to take ball bearings, D is a flange shown somewhat enlarged so as to take bolts to secure the hub cap. This is the latest practice, as the caps used to be threaded on

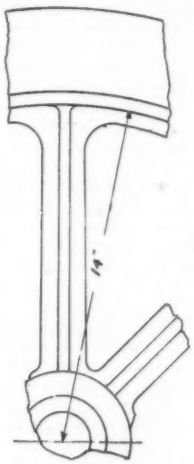
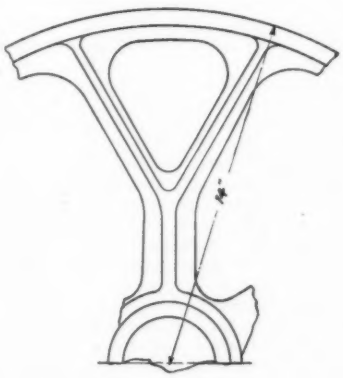


FIG. 4.

the boss, but it was found difficult to keep them from coming loose. The same flange will be seen in Fig. 3. The bore of the wheel in Fig. 3 is plain, and in most cases is fitted with a floating bush. It will be seen that coring is largely used in these wheels, but this has always been the practice with these steel castings, so iron castings would not be handicapped in this respect.



FIG,. 5.

We now come to the consideration of substituting cast-iron for steel castings. The dotted lines on the figures show what in the writer's opinion would be the extra amount of metal required.

As steel castings are heavier bulk for bulk than iron castings, we do not think that wheels of the latter should be more than 15 per cent. heavier than the former, and this would be approximately the weight of a wood wheel for the same type of vehicle. It is quite possible that this weight might be reduced, and the cast-iron wheel might eventually be practically the same in this respect, as the cast-steel one, because, as before pointed out, the latter are much stronger than would otherwise be necessary if they were free from flaws, and not so subject to deterioration through fatigue. This is why any test such as breaking a pair of the wheels by blows of a falling weight would not be a fair comparison, for if the steel wheel had not been subjected to any fatigue by being run on the road, it might show a great excess of strength, whereas if it had been in use for some time it might fail easily. The examples shown are the practice of leading British and Continental firms.

The Influence of Copper upon the Physical Properties of Steel.

In a Paper read before the American Institute of Mining Engineers, Mr. G. Howell Clevenger deals at some length with the influence of copper in steel, as affecting its various physical properties, finally arriving at the following conclusions: (1). In making copper steel by the crucible process it is necessary to "kill" the metal before adding the copper, and just before pouring it is advisable to add a small amount of some deoxidizing agent. (2). In forging the ingots, containing from 0.437 to 0.605 per cent. of carbon, traces of "red-shortness" began to be shown with a copper content of 4.512 per cent. Up to this point the steel forged about like machine steel. (3). Up to 0.846 per cent. of copper the steels experimented upon gave satisfactory welds. At 1.857 per cent. the weld was much weaker and above this point the steel could not be welded. (4). There appears to be a marked tendency for copper to eliminate sulphur. (5). In the series of steels studied the segregation of copper toward the bottom of the ingot begins to be slightly noticeable with 0.846 per cent. of copper. With 2.773 per cent. of copper the segregation is more noticeable and with 4.512 per cent. of copper it is very marked. (6). The presence of small percentages of copper up to 0.493 per cent. has a most marked effect in preventing the corrosion of steel by dilute sulphuric acid. As the percentage of copper increases, the loss by corrosion increases, until with 2.773 per cent. of copper the loss is greater than when the steel does not contain copper. (7). As the percentage of copper increases the structure becomes finer, due to the more even distribution of fibrous cementite. This is more apparent in the forged than in the annealed specimens. (8). The point Ar_1 was lowered from 730 degrees C. in the steel containing no copper to 635 degrees C. in the steel containing 4.512 per cent. of copper. (9). The elastic limit in both the annealed and the unannealed specimens increased steadily until with 4.512 per cent. of copper it was increased more than 100 per cent. over that of steel containing no copper. Within the limits investigated the ultimate strength appears to increase almost in direct proportion to the amount of copper present. With the unannealed specimens the actual breaking strength in all cases was the same as the ultimate strength. The actual breaking strength in the case of the annealed specimens shows an increase with the increase of copper. In the annealed specimens the elongation is somewhat irregular, but in general decreases up to 1.857 per cent. of copper and then increases and reaches a maximum at 4.512 per cent. of copper. The general tendency in the annealed specimens is to decrease the elongation up to 1.85 per cent. of copper and then up to 4.512 per cent. of copper to gradually increase it. In the unannealed specimens the general tendency is to decrease the elongation throughout the series. (10). The hardness of the steel increases with increasing copper content and corresponds fairly well with the tensile tests.

The Genesis and Development of the Foundry Cupola.

At the meeting of the Sheffield Branch of the British Foundrymen's Assocation on Tuesday, November 18, Mr. Thos. Firth (President of the Branch) in the chair, Mr. Robt. Buchanan, F.R.S.A. (Past-President of the Association), gave a lecture entitled "The Genesis and Development of the Foundry Cupola."

MR. BUCHANAN said the genesis of the cupola could be seen to-day in India, Africa and other parts of the world where ironmakers still followed the primitive methods which preceded present-day methods in more advanced civilisations. After a reference to the antiquity of iron—as indicated by the discovery of hinges on the doors of the pyramids—Mr. Buchanan traced the development of the early types of furnace to the bloomery furnace, which sometimes produced wrought iron, and which by the raising of the tuyere produced cast iron. Charcoal was the fuel, and to show how long these furnaces had been in use he mentioned that in the Forest of Dean, and over a period of 300 years, 20 blast furnaces used the slag from these bloomeries as a substitute for iron ore. The slag contained from 30 per cent. to 40 per cent. of iron. The bloomery furnace was the true progenitor of the cupola as known to-day. The first castings of iron of which we had authentic knowledge were cannon made by Ralph Hogge, at Buckstead, in Sussex, in 1543. Peter Baude, a Frenchman, was employed by Hogge, and later seems to have begun business on his own account. Baude had an apprentice named Thomas Johnson, who surpassed his predecessors in the work he did. In 1595 Johnson cast for the Earl of Cumberland 42 cannons, each 6,000 lbs. The lecturer thought it clear, however, that the casting of iron had been in use long before 1543, because skill in moulding smaller articles would certainly precede the casting of cannon. It was somewhat remarkable that it was 160 years after the first cannon was cast by Ralph Hogge, that the first cast-iron pot was made at Bristol by the first Abraham Darby, father of the Abraham Darby who founded the Coalbrookdale Works in Shropshire.

Mr. Buchanan next dealt with the important advances resulting from Dud Dudley's discovery of how to coke coal, when in consequence of the cutting down of the forests the supplies of charcoal had declined. That coke was more difficult of combustion than charcoal was shown by the adoption of larger bellows, and this step led to the substitution of the rotary fan and the development of the cupola on its modern lines. Mr. Buchanan described the various types in detail and their method of working, incidentally issuing a warning against the common practice of lighting the bed too early and having it in a melting condition before the blast went on; such conditions would give the dullest iron. He had found the best results were got, especially with the first metal, when the bed was simply kindled up a bit above the tuyeres, and not all thoroughly burned, because by burning it too much the calorific power of the bed was wasted. Melting only took place in a certain well-defined area, in good heat, above the tuyeres, that heat being largely conditioned by the power of the blast. If the blast was strong the melting zone was increased in height. Mr. Buchanan illustrated by diagrams the greatly increased efficiency of a bell-mouthed tuyere as compared with a right-angle entrance (95 per cent. as against 45 per cent.).

In regard to the lining of the cupola—usually of fire-brick, and repaired with ganister, fire-clay or other siliceous material—Mr. Buchanan described some experiments he had made with linings of another sort. He was induced to try what results could be got with a lining similar to what was used in Bessemer vessels—magnesian limestone, or dolomite and boiled tar. His experience however, was a somewhat unhappy one. He rammed up this dolomite round the plug and so carried the lining pretty well up to the top, where the junction of the ordinary fire-brick and the dolomite would not be subject to much heat. He was using one of Thwaites's cupolas, and towards the end of the first blow he saw some drops of metal coming through the connector brick. He got these drips stopped, and ran through the cast. It was then found that the connector brick had been cut into a deep groove by the slag, showing that the basic slag which was formed from the waste of the dolomite during the melting had cut away the silica brick very seriously. The idea of the metallurgical chemist who had recommended this was that in dolomite one would have a lining which would be practically subject to no waste at all—very desirable if it could be obtained. Continuing the experiment, Mr. Buchanan made up flush again and laid flat bricks to take up the wear. There had been a run-out at the door which was made up with sand because, as was found out afterwards, the basic slag had eaten away the sand. His "week's enjoyment" ended with a large piece of the lining blown out. There had been wet weather, and some rain had got in a crack in the shell, and, as Bessemer people would know, when moisture and dolomite were in conjunction, "something is going to happen." When he had burned a hole in the shell about 12 or 14 in. round, he thought it was time to give up the experiment. Thus this lining which was not going to wear away, lasted actually about five blows, and he was very pleased to get back to the old fire-brick lining, which with all its drawbacks certainly had distinct advantages over dolomite.

Mr. Buchanan next tried lining with anthracite dust and boiled tar—though, he added, one wondered now what he must have been thinking of. From a pyrotechnic point of view it was perfectly satisfactory. There was no need for any gas flares or electric light round the cupola, because they had a flame at every crack and cranny in the shell. (Laughter.) He stopped experimenting at that point and went back to the old shell because while it was very interesting it was not altogether conducive to business success.

Dealing with the types of drawn-in linings, such as in Thwaites's cupola, Mr. Buchanan said this certainly effected a saving of coke and hastened the melting, his explanation being that with a blast directly under the wider area of the cupola very rapid combustion all over it was obtained. Deville, the noted French inventor, who was the first man to melt platinum, made a small furnace in which to use a crucible; the bottom of his furnace had a number of small holes, about $\frac{1}{8}$ in. in width, set at stated intervals, and the crucible stood on a brick in the middle. Mr. Buchanan made such a furnace and got a temperature by means of these small tuyeres or air-holes that he had never seen in any furnace since. It was so hot that it had the effect on the eyes as of looking at an

electric light. It certainly was very wasteful on the crucible, but one got a great temperature with the blast distributed in that way round the crucible. His idea was that by the drawing-in of the cupola one repeated to some degree the same kind of conditions—the interstices between the coke acted as so many small air-holes, and one got a very high temperature.

The Doherty casting process was the subject of some experiments 16 or 17 years ago which the lecturer described in detail. The idea of the inventor, a Canadian, was that by blowing in a certain amount of steam at a high temperature certain marked advantages were obtained, one of which was economy, the prospectus of the Company claiming that a reduction of 7s. per ton in the course of melting was made possible. There was a small steam jet at each tuyere, the steam being maintained at a pressure of 120 lbs. per sq. in. It was claimed that by this means cheap low-grade iron could be used for the production of first-class castings; the idea was that the steam when it came into contact with the white-hot coke dissociated into hydrogen and oxygen. The hydrogen was supposed to reduce any oxides present, and, of course, the oxygen helped the combustion of the coke. Later, a ring with a lot of holes, similar to that in a Bunsen burner, was substituted for the jets in the tuyeres. The process did not, however, come to much. It yielded one result which he had never seen since—when the furnace was melting well one could cast a 1¼-in. square bar which, when held in a vice, could be hammered out until the edges were overhung by an eighth of an inch. He had never seen that result obtained with ordinary cast iron. Mr. Buchanan added that he had seen the process in use in North Staffordshire, where the foundry manager said it gave him cleaner and solider castings than he had ever got before with any mixtures of iron. So far as he knew, however, the process had now died out entirely.

Describing some of the most common types of cupola at present in use, Mr. Buchanan spoke highly of the Machiel, a modification of the Thwaites, the main difference being that the receiver was directly under the cupola. It was, he said, a very economical one, and gave hot metal. The Whiting type was also much liked by Birmingham users. It also was a very rapid melter, and the cupola which was making the best products in Britain today was a modified Whiting. The user of this adopted higher auxiliary blasts (of which the Americans did not approve) so as to get fuller combustion, and he (Mr. Buchanan) thought this man was doing the most remarkable melting, as regards economy, of any one in Britain, and probably in the world. He had seen his records, and if he told them what he had seen he would hardly be believed. He melted enormous quantities, regularly drawing off from 100 to 130 tons, and obtained from 16 to 17 lbs. of iron to one of coke, and occasionally above that. Mr. Buchanan also dealt briefly with the Herbertz cupola—the invention of a German iron-founder. It consisted of two parts adjustable vertically, and combustion was assisted by means of a steam jet near the closed top which caused a vacuum. This type was fairly successful in small sizes, but with larger sizes there was constant trouble with the middle of the cupola not melting; and, taking all points into consideration, the drawbacks were greater than the advantages. Very few were in use in this country.

The speaker next proceeded to relate some interesting particulars of experiments he had carried out as to the use of gas as a fuel. With an ordinary type of cupola he filled up in the usual way, and connected up with the tuyeres a gas-pipe in such a way that gas and air mingled in the tuyere. The heat obtained was not reached so quickly as when he set out to burn coke by itself, but he went through with the whole melt and took out of the cupola at the end of the melt practically as much coke as he had put in at the beginning. His idea was that the burning air and gas would be consumed in preference to the coke itself, and he found that that worked out all right. Other pressing matters prevented his continuing the experiments, but he believed it was quite possible that such a process might prove effective and economical. A number of years ago Messrs. Riley & Dick, of the Steel Company of Scotland, brought out a gas-fired cupola absolutely gas-fired They connected the cupola to a Siemens furnace, and the gas passed along the furnace and up the cupola. They melted iron quite effectively, but their difficulty was in maintaining the lining, for which reason the process was abandoned.

Many experimenters had resorted to various expedients for applying hot blast to cupolas. Some had put a series of pipes in the upper part of the cupola, and the flames playing round these pipes heated the blast as it passed along them. That was not an experiment he would try, because there ought to be no flame in the cupola unless it was when blowing down, so that to adopt that system successfully would mean that they were following bad cupola practice. The only time when, to his mind, the pipes would be heated, would be when stopping down, and that was a little too late. The Barrow Company used a hot blast in their cupolas for melting down a part of the hematite that was used in the steel-works, and one of their officials had told him that it certainly did save coke. But there the air was being heated, in any case, for the blast furnaces, and so cost practically nothing. If one had to heat the air by an additional use of fuel he doubted if there would be any economy. That official had also told him that by the use of the hot air there was less loss of silica than when using a cold blast, but that, thought Mr. Buchanan, wanted some explaining.

The charging of cupolas by mechanical means was next dealt with by Mr. Buchanan, who doubted its effectiveness for high-class work, such as engineering castings, hydraulic work, etc. He did not know whether such thorough mixing could be obtained as by hand, especially where one was using two or three qualities of iron in an afternoon in one cupola. Where he had seen mechanical charging in operation it had admittedly broken up the lining very badly at the side further from the point where the mixture was tipped in. The manager of those works, however, while admitting that the system had its drawbacks, thought its advantages outweighed these, and after some hesitation said if he were putting up other cupolas he would have mechanical charging.

Discussion.

The PRESIDENT asked whether there was a big advantage in the different tuyeres now in use. At the works with which he was connected there was a very old cupola in which the blast was from two sides, hitting the opposite side of the cupola with the air, and they found that this was very destructive to the lining. He was hoping Mr. Buchanan would have told them more of his experience with various tuyeres, because he knew he had had a very wide experience with them. He agreed with him in regard to mechanical charging that this was all right where there was a very big blow and all the metal was fairly uniform, but in Sheffield district their work was so varied that he thought it would be absolutely impossible to use anything of the kind. He would be glad if Mr. Buchanan could give them some data as to the quantity of coke used with different qualities of iron, both hematites and common iron.

Mr. J. R. Hydes regarded as one of the most interesting matters brought out in the lecture the increased efficiency of the trumpet-shaped tuyere; but to get the maximum efficiency he thought it should be trumpeted both ways, and not at one end only. In West's book on the cupola, added Mr. Hydes, he mentioned that the efficient tuyere area was not exactly the area of the tuyere when looked at; it was necessary to take into consideration the fact that when in use it was blocked up, more or less, by lumps of coke, so that, although the blast had free access at the bell end, yet at the other end its passage was obstructed, so that they might safely double its area, and so gain considerably. In regard to the Doherty process of using steam, it had to be remembered that the products of combustion had to be warmed up to the same heat that was being generated, and, as they knew, steam absorbed considerable heat in warming up—far more than ordinary gases, such as air or CO_2, or nitrogen, for that matter, and, consequently, when the steam was put in they might get a very high temperature from burning the hydrogen, but would have to give it back in raising this obstinate steam to a very high temperature. His father (added Mr. Hydes) had a little to do with the Doherty process, and his results were something like those of which Mr. Buchanan had spoken. With reference to the use of anthracite or coke dust and tar, they would find that if they rammed it anywhere and kept the air from it it would be of some use for filling in any odd corners of the cupolas, or it could be rammed behind the fire-bricks safely. It was far more serviceable than fire-clay or ganister, if only the air was kept from it. He would like to ask Mr. Buchanan a question with reference to the blast pressures. When the cupola was narrowed, as shown in Thwaites's design, he believed the blast pressure was invariably raised; was it not quite possible by keeping the cupola straight, and with adequate tuyere area, to lower the blast pressure and get exactly the same result?

Mr. Buchanan said, as regards the President's question about the consumption of coke, it was his practice never to say what could or could not be done unless he knew the particular conditions. It was an economical consumption of coke which gave them hot metal, suited for the particular work concerned, the particular conditions being considered. If one took a very efficient type of cupola and practice and laid it down that the consumption of coke in that case was correct it would only apply where the same kind of work was being done under similar conditions. He regarded it as very unwise to say what should be the quantity, because the conditions varied so greatly. Given ideal conditions he was quite prepared to say what coke should be used. In regard to the wasting of cupola linings, of which Mr. Firth spoke, he (Mr. Buchanan) described some experiments he had undertaken. He shut off one tuyere and found, as a result, that he melted the iron on the opposite side, from which he concluded that one blast baffled the other and distributed the melting far better. If they had two converging tuyeres blowing towards one side of the cupola, they would find on the side where the effect converged, wasting of the linings, because the temperature was higher. That brought him to Mr. Hyde's question about contracting the cupola, as in the Thwaites and Machiel types; in regard to blast pressure as affected by the drawing in or opening out, it was quite obvious that with the full size of the cupola available the air would pass more readily, but he had done very good melting with a Thwaites cupola—8.5 lbs. of iron with one of coke, running castings ranging from one ounce up to two or three tons; half the metal, say, seven or eight tons, went into castings about $\frac{1}{2}$ in. and some $\frac{1}{8}$ in. in thickness, and the metal had to be carried in hand ladles for about 100 yds.; 8½ lbs. was taken as the average over a month—not individual cases—and every bit of coke, including the bed, was included in the quantity giving one pound of coke to the 8½ lbs. of iron.

Then, in regard to the bell mouthing of tuyeres, he believed Mr. Hydes was fairly correct. In connection with the blast pressure, he was sorry he had forgot to mention the work which Mr. F. J. Cook, of Birmingham, had done in relation to this matter of blast pressure and tuyere area, and these, in turn, as related to the diameter of the cupola. Mr. Cook had drawn up a formula which would be of the greatest possible use in allowing the iron-founder to so balance the pressure, tuyere area and cupola area, that he could get the conditions which would give him the highest output possible for his cupola. He was certain that had never been done before. He had experimented on one of the Machiel cupolas, and after many trials, got out certain data, and to prove whether his data was correct or not he altered one of his other cupolas to his own formula, and found it answer perfectly—he got in practice what theoretically his formula indicated he ought to get.

Mr. J. G. Crowther (Vice-President of the Sheffield Branch), in seconding a vote of thanks to the lecturer (which was heartily accorded), said there was one question he would like to ask in connection with the waist of a cupola—did not Mr. Buchanan think that such a waist as he had spoken of would give a quicker draught just as would be got in a natural-draught furnace?

Mr. Buchanan, in reply, said he feared that in the designing of cupolas they thought very little about the draught side of the question, especially as they always had a charging door to work on the furnace. It did not matter how high was the chimney, they would preferably draw from the charging door, so that the height of the chimney was considered more from the point of view of keeping the flame from the men or carrying the flame up higher than the roofs, but very seldom from the draught point of view, because they had a positive blast at their command.

A New Alloy.

A brief paper, read by Dr. F. Zimmermann, of Baker & Company, Newark, New Jersey, before the American Electro-chemical Society, gives an account of a research made to find a substitute for iridium-platinum, on account of the growing scarcity of iridium. Highly-refined platinum and osmium have been successfully combined in widely varying proportions, yielding alloys of commercial value. While the two metals may be combined in almost any proportion, alloys containing from 1 to 10 per cent. of osmium and 99 to 90 per cent. of platinum are chiefly used. Great purity of the components is essential, as the presence of small percentages of other elements appears to be very detrimental to the properties of the resulting alloy. According to the chemical and physical behaviour, it seems that one part of osmium in an alloy with platinum will take the place of two and one-half times its weight of iridium. The osmium-platinum alloy is very acid-resisting, and for this reason may be of great service in the electro-chemical industry. Its electrical resistance is considerably higher than that of an iridium-platinum alloy of the same percentage composition. The alloy further possesses great hardness and tensile strength. Wires of the finest size are drawn with comparative ease.

Repairing Broken Castings by the Fusion Process.

By F. R. Parsons.

A broken casting, if at all repairable, is, as a matter of course, sent direct to the machine shop, there to be dealt with by mechanical methods; that is to say, methods which include either plating, riveting, bolting, pinning, or dowelling. If, after mature consideration, it is deemed a case in which it is either inexpedient to waste time on, too expensive, or too much in the nature of an experiment, then is it decided to consign it to the scrap-heap. This oftentimes entails a prolonged wait before a renewal is forthcoming. A pattern has to be provided by the pattern shop, and then when it ultimately emerges from there in wood the foundry foreman perhaps experiences a difficulty in sandwiching it in between his regular jobs; so it waits a suitable opportunity—and his pleasure. The consequence is that by the time it reaches the machine shop, a week, perhaps, has been lost; though in nine cases out of ten this could have been avoided had the firm possessed a little practical knowledge as to how to fuse the broken part.

Now, before proceeding with the instructions for fusing or burning together broken castings, together with the application of the art, it would doubtless

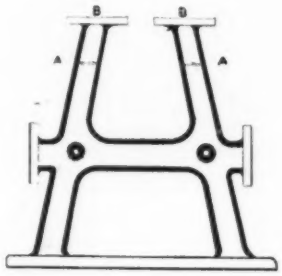


Fig. 1.

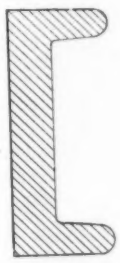


Fig. 2.

be best to briefly consider of what the process really consists. As its name implies, it means the fusing together of two separate portions of a casting and the interposition of a new section of metal to replace that burnt out during the process. Strangely enough it has been the writer's experience to find that the average moulder and mechanic regards it with considerably more condemnation than favour, and doubtless for the reason that unless the operation be conducted on strictly scientific lines, started and finished by one who is somewhat accustomed to the art, and, moreover, appreciates the pitfalls as well as the possibilities involved and in the operation leaves nothing to chance, it is safe to say that the number of failures will exceed many times the number of successes; and it is these unfortunate failures which have damned the process. With the first failure has been born scepticism; with the second unbelief; with the third utter condemnation. But the writer can, from personal experience, cite many cases where a successful "burn" has saved him hours of vexatious delay. One in particular was a rail-lowering gear bracket of a "Pond" planer. This, from some unaccountable cause, snapped through the curved web, and so put the machine out of commission. It occurred somewhere near the middle of one afternoon. A hurried consultation with the foundry chief brought about a decision to fuse it; and within an hour and a-half the metal was being poured to heal the fracture. That same evening the casting was exhumed, cleaned off, and fixed in position; and at the usual hour the following morning the tool was in full work again. This occurred quite four years ago, and the bracket is doing duty at the present time.

Fig. 3.

It must be admitted, however, that there are certain limitations beyond which it is impossible to go, just as there are conditions which it would be impossible to meet. For instance, the process of fusion calls into existence the laws of expansion and contraction—expansion when the surrounding parts are being heated by the liquid metal, contraction when the parts are cooling. If the shape or formation of the casting is such as to have a tendency to repress or confine the inclination of these laws during the operation, then the attempt had far better not be made, because the chances of failure are about a hundred to one. As an example, a cast-iron pulley with one or more of the arms cracked would constitute such a difficulty, since it is manifestly impossible for the rim and boss being both cold during the

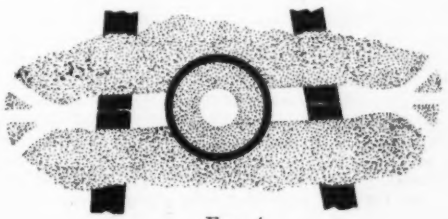


Fig. 4.

operation, to permit the free operation of the aforesaid laws. But any casting in reason which is not subjected naturally to confined strains set up during manufacture may be regarded as being suitable for this particular class of repair.

It has frequently been put forward, both by writers and workers, that it is impossible to successfully fuse new material with old in this direction; that is to say, to insure perfect strength, and homogeneity

where the new metal joins the old. This, however, can be proved a fallacy. Provided adequate safeguards are employed to carry away the gases generated during the process, and that sufficient metal is at hand to bring the fractured edges and its near surroundings into a state of fusion and at a temperature equalling that of the new metal, that ample provision is made by means of vents against sponginess, there is not the slightest reason why the repair should not be as strong and in many cases stronger than the casting was before.

The writer recently witnessed a most successful case of fusion treatment applied to a fairly large cast-iron H frame—part of a printing machine. Fig. 1 represents in elevation this casting; the fractures being indicated at A, A. The casting, which weighed upwards of 2½ cwt., was about 3½ in. wide at the fracture, the body of it being of $\frac{5}{16}$-in. metal, webbed on one side only, the metal in the webs being $\frac{3}{8}$ in. thick. An enlarged section at this point is shown in Fig. 2. Preparatory to the casting being sent to the foundry, it was scrupulously cleaned of all paint and grease around the fracture—being passed through a fire, in fact—and a machined strip bolted to the bearing faces, B, B, in order to maintain exact location and insure correct alignment. This done, it was passed on to the foundry, where a space on the floor was levelled off to receive it. The first care was to bed it firmly down in the sand, web side downwards, the face of the casting fair with the foundry floor. The whole was then levelled through both ways with a spirit level and straightedge, care being taken that the joints came closely and accurately together; whilst the ends of the casting were left free to expand or contract at will.

A layer of sand, 3 to 4 in. in depth, was then shovelled over the casting and carefully rammed; a channel 3 in. in width being provided transversely across the casting, the cracked portions of which formed the centre of the channel. From the ends of this main channel diverged other smaller ones, their purpose being to receive the overflow metal when pouring. A cast-iron ring, 12 in. diameter by 9 in. high, was next lined with sand and placed centrally both with the channel and the casting on the raised floor, and packed firmly around; this forming a common inlet for the metal to either channel. The general arrangement is clearly shown in Figs. 3 and 4.

Now it follows that the first part of the operation consists in melting out the old metal surrounding the fractured portion—in this particular instance a rather lengthy operation and one involving a deal of metal, owing to the presence of the webs and the fact of their being imbedded in sand. (It may here be mentioned that a flat object is invariably easier to treat than one having webs.) A ladle holding about 3½ cwt. of metal was used, the pouring being directed through the central ring. To the eye of the average intelligent moulder it is fairly obvious when the parts are in a molten condition; but in any and every case is it desirable to have in reserve a superabundance of metal. When it is thought that the flowing metal has burnt out the old portion, due to the passage of the hot metal over it, it is only necessary to sound the "cease fire," when the metal will flow away naturally, leaving the mould full of the new metal up to the level of the old casting.

The precautions to be observed in all operations of this kind are obvious and simple. See that the casting to be fused is absolutely free from paint, dirt, or grease, or any matter tending to induce blowing; and that the sand in and around the fracture is thoroughly vented, otherwise a spongy mend will result. Also put no obstacles in the way of free expansion and contraction.

British Foundrymen's Association: Halifax Branch.

The annual general meeting of the Halifax Branch of the British Foundrymen's Association was held last month, Mr. Hugh Campbell (President) in the chair. The officers elected for the ensuing session were: President, Mr. Hugh Campbell, M.I.Mech.E.; Vice-Presidents, Mr. W. S. Milligan, M.I.Mech.E., and Mr. V. S. Milligan (Sowerby Bridge), and Mr. R. Carrick (Shipley). Committee:— Messrs. A. Love, W. Smith, A. Midgley, F. Limb, F. Berry, A. Brearley, H. Hurst, H. Hanson, T. J. Dibb and T. Dean. Secretary: Mr. J. G. Robinson.

Mr. H. Campbell, on his election to the office of President for the third successive year, stated that he believed in the officers of the Association being frequently changed, as new blood often brought new ideas.

Mr. J. Crowther, B.Sc., Principal of the Municipal Technical College Halifax, in addressing the meeting on the education of apprentices, brought particularly to the notice of the members present the evening classes in ironfounding held at the College, and invited the Association to select a visiting committee in connection with the same. The following members were elected:—Messrs. F. Berry, R. H. Pickles and T. J. Dibb. In compiling the next syllabus of lectures it was decided to arrange for one to be given at Bradford and one at Leeds.

Electric Steel in Sheffield.

Some useful data have been published regarding an electric furnace at the works of Messrs. Darwin & Miller, Sheffield, which has a capacity of about 3 tons and has been in use some two and a half years. It is of the two-phase type, the two electrodes being connected to each wire of the system, the bottom electrode, which projects through the bottom of the furnace, serving as a common return to both phases. The electrodes are amorphous carbon 12 in. diameter by 5 ft. long, and as it is consumed a new electrode is screwed into the end of the old one. The joint is packed with tar and graphite to improve the contact. When the furnace has been charged, a current of 4,000 to 5,000 amps. at 55 volts is maintained for two to three hours, during which time the melting is completed. Oxidising and desulphurising slag is added, which is subsequently neutralised by the usual lime slag. During the latter stages the current is reduced to 2,500 to 3,000 amps., and the refining stage, which occupies two to three hours after the charge is melted, is completed, and after analysis the necessary ferro-vanadium or ferro-titanium is added. A typical charge is as follows:—2 tons 2½ cwt. of rail-end scrap, yielding 2 tons 2½ cwt. of tool-steel ingots. Chemical composition of charge C=0,38 per cent., S=0.06 per cent., P=0,09 per cent. Charging commenced 1 p.m., current switched on 1,25 p.m., charge melted 3,30 p.m., current switched off 5.50 p.m.; total time, 4 hours 50 minutes.

A New Brazing Process.

According to a Paper on "The Use of Gas for Industrial Purposes," recently read by Mr. H. M. Thornton, J.P., before the British Commercial Gas Association, an engineer associated with the Indian Railways, has introduced a new brazing material in connection with which the use of town gas is advocated. Heavy castings, such as large gear wheels and embossing presses, which have been fractured, have been successfully repaired with the new brazing material by the use of gas blow-pipes.

The Use of Steel Ingot Moulds.*

By F. Amende.

In consequence of the unsuccessful results obtained with ingot moulds of hematite iron, experiments were made for the purpose of discovering a more suitable material, in view of the importance of the outlay on ingot moulds with reference to the cost per ton of steel produced. The average life of the moulds was about 100 ingots, and all attempts made to obtain any decidedly better result proved fruitless, until recourse was had to steel. Looking back, it is now somewhat astonishing to remember what a long time was required to recognise the suitability of steel as a mould material. It is true that the objection to steel on the ground that the moulds will not stand water-cooling is justified, but this defect only appears in the case of works where there is insufficient space available for cooling down the ingot moulds in the air, it being essential to lower the temperature of the red-hot moulds to the working temperature gradually. It may be that a class of steel which will stand rapid cooling will be evolved, but the author has abandoned his attempts in that direction, and at the Völklingen Works, where the cooling space is limited to the accommodation of 100 ingot moulds, only those made of grey cast iron are now cooled with water. This two-fold method, however, is not advisable, since it occasionally happens, especially in night shifts, that a steel mould is put into the water tank by accident, with the result that it is found to be cracked next day. For cooling with air, the moulds are set up on a girder grating, and subjected to a cold blast until reduced to the required temperature. Given sufficient space, however, the blower could be dispensed with, the time required for cooling being then about seven hours in place of four. The actual time depends on various circumstances, and an undoubted improvement could be introduced by placing between two rows of hot moulds a row of moulds that are out of use for the time being, these latter being warmed up by the hot moulds for use in case a change of moulds should be required.

FIG. 1.—MOULD FOR CASTING STEEL INGOT MOULD.

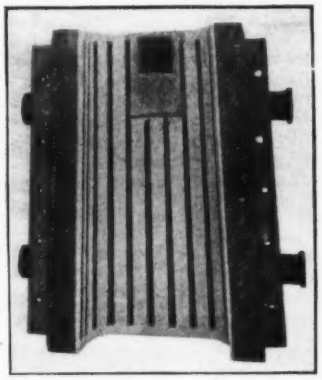


FIG. 2.—GROOVED MOULD.

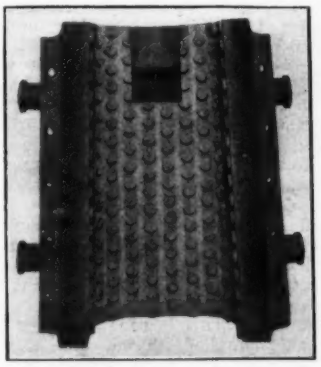


FIG. 3.—STUDDED MOULD.

With regard to the best kind of steel to use, comprehensive experiments have decided in favour of one with a tensile strength of about 70,000 lbs. per sq. in. A soft standard quality, with a little added silicon, gave a life of about 150 pourings, which was not satisfactory; and the same applies to a metal of about the same composition as rail steel, but giving somewhat higher test values. It must not, however, be assumed that rail steel with about 0.4 per cent. of carbon necessarily gives poor results; for it is probable that further trials might be attended with success. Nevertheless, having plenty of uses for the so-called medium quality, the author gave this the preference, for the time being at least. An indisputably great advantage in connection with the production of steel ingot moulds is that basic steel carburised with spiegeleisen or other additions is admirably adapted for the purpose. A highly desirable feature is to obtain a steel that will pour quietly. To obtain this, the well-blown charge is left in the converter two or three minutes longer than usual, and in pouring the moulds are topped up a few times, with the result that difficulties due to piping are obviated. Three to four ingot moulds are cast from a charge, the rest of the metal finding abundant application for medium-hard grades or for making other moulds for the steel casting shop.

The moulds for casting the steel ingot moulds (Fig. 1) are of the same material as those used for casting the grey-iron moulds, and are lined with firebrick, faced with about $\frac{1}{4}$ in. of moulding composition. An important point to observe in preparing these moulds is to have them thoroughly dried, which is best effected by placing them in the centre of a ring of red-hot ingot moulds, or else in the drying oven. The blacking composition is applied when the moulds are quite dry. The cores are composed of fairly thick cast-iron core shells surrounded with straw, over which the moulding composition is applied in several layers (total thickness about $2\frac{3}{4}$ in.), each layer being dried in the oven before the next is put on. This careful treatment of the cores has been found to answer satisfactorily. After the final drying the cores are blacked. When the moulds—which are arranged for bottom pouring—have been assembled, they are placed in the cast-

* "Stahl und Eisen."

ing pit and surrounded with red-hot ingot moulds, in order to warm them up properly. After pouring, the moulds are left intact for 2 to 3 days, in order to ensure very gradual cooling.

Numerous trials have been made with moulds of different construction, such as shown in Fig. 2, containing a series of parallel dove-tail grooves all round, or, as shown in Fig. 3, provided with internal studs, the recessed portions being coated with moulding composition. The rest of the treatment was the same as in the case of Fig. 1. The author, however, prefers the older form as being apparently more reliable, since it allows the cast ingot mould to cool down more slowly, without chilling the steel, as is the case with the grooved or studded moulds, and, therefore, lessens the risk of longitudinal cracks. It should, however, be mentioned that a fine longitudinal crack does not affect the life of the ingot mould, and there is no tendency for the ingots to stick against the sides; though, for certain purposes even fine cracks may be undesirable.

The results obtained with steel ingot moulds were at first irregular, some of them having only a very short working life. In most cases, however, this could be traced to special causes, viz., lack of experience in working with steel moulds, exposure to rain in the casting shop, and placing steel moulds in the water tank by mistake. The number of these moulds made up to April of the present year amounted to 139, each with a nominal capacity of 4 tons, though the actual weight of the ingots is only about 3¾ tons. Of these, 20 were discarded in 1912, the number of ingots poured ranging from 26 to 704 with different moulds, and the average number of pourings per mould being 273. In 1913, up to the end of April, the results were better, the average for nine discarded moulds being 378 ingots.

The life of the moulds and cast-iron core shells used for casting the steel ingot moulds is almost indefinite, this being natural enough, seeing that they do not come into direct contact with the molten steel at all. The moulding composition consists of 7 parts of Belgian sand and 3 parts of burnt clay, that for the cores being 2 parts sand and 1 part burnt clay. This is renewed after 6 or 7 pourings, but only patched up between whiles. The cost of making the steel ingot moulds amounts to 6s. 3d. per ton, including mould, core, gate, hopper, top and bottom members, and labour for fettling. This is capable of reduction, because at present the ingot moulds are conveyed to and from the cooling store by the steel-foundry crane, so that there are frequent delays. The general expenses, including a due proportion of the establishment and capital charges, amount to 17s. 6d., and the steel for the ingot moulds (allowing 6 per cent. for waste) costs 67s. 3d., so that the total cost of the ingot moulds is £4 11s. per ton.

Iron and Steel Institute.

Mr. G. C. Lloyd (Secretary) informs us that Thursday and Friday, May 7 and 8, 1914, have been fixed as the dates of the next annual meeting of the Iron and Steel Institute. The annual dinner will take place on Thursday, May 7, at the Connaught Rooms, Great Queen Street, W.C. By the kind invitation of the Comité des Forges de France, the autumn meeting will be held in Paris, the dates of Friday and Saturday, September 18 and 19, having been provisionally fixed for the business sessions. The first half of the following week will be devoted to excursions to the chief iron-mining and manufacturing districts of France. The Bessemer Gold Medal for 1914 will be awarded to Dr. Edward Riley, F.C.S., F.I.C.

Cobalt High-Speed Tool Steel.

In a recent issue of "Stahl & Eisen" appears an article by Professor Schlesinger, of Charlottenburg, giving an account of tests of the new cobalt high-speed tool steel. Of special interest is the composition of one particular cobalt steel, and for the sake of comparison the analysis of one of the ordinary high-speed steels used in the tests is also given in the following table:—

	Cobalt steel "U," per cent.	High-speed steel "N," per cent.
Carbon	0.76	0.88
Silicon	0.28	0.28
Manganese	0.10	0.07
Phosphorus	0.010	0.018
Sulphur	0.032	0.036
Copper	0.06	0.07
Nickel	trace	0.06
Cobalt	5.03	None
Chromium	4.38	5.09
Tungsten	16.40	18.10
Vanadium	0.62	1.16
Molybdenum (about)	0.30	0.60

The author states that the percentage of cobalt in this sample is rather high. Each steel was made to cut hard chrome-nickel steel of 65 tons tensile strength in a lathe until the tool was dull, at a speed of 83 and 66 ft. per min. with a feed of 1 mm. per revolution and a cut of about 4 mm. thickness; and mild steel of 31 tons tensile strength in the same lathe at a speed of 83 ft. per min. with a feed of 2.5 mm. per revolution and a cut of about 10 mm. thickness; also cast iron of about 10 tons tensile strength at a speed of 100 ft. per min. with the same feed and cut as the mild steel. The results of the tests under these conditions of the two steels referred to above are as follows, including one other cobalt steel which ran unusually high:—

	On chrome nickel steel 83 ft. speed.		On chrome nickel steel 66 ft. speed.		On mild steel 83 ft. speed.		On cast iron 100 ft. speed.	
	min.	sec.	min.	sec.	min.	sec.	min.	sec.
Cobalt "U"	5	6	13	54	6	22	9	55
High speed "N"	1	47	5	20	2	52	1	25
Cobalt "S"	5	26	25	36	—	—	—	—

High-speed steel "N" is chosen for the above table as the one out of the number shown in Professor Schlesinger's tables which gave the best results of the ordinary tool steels. The end of each test was determined by the dullness of the tool, ascertained scientifically. To make the comparison complete, the value of each grade of steel was determined by dividing the endurance value by the price. The result of this on the hard chrome-nickel class in the case of the three steels mentioned was as follows:—

	On chrome-nickel steel at 83 ft. speed.	66 ft. speed.
Cobalt "U"	40.80	111.50
High speed "N"	7.93	23.70
Cobalt "S"	43.50	205.00

Professor Schlesinger concludes his article with the statement that the application of cobalt to the production of high-speed tool steels exerts a marked influence in enhancing the value and endurance without raising the cost price over the average market price.

Mr. S. Steel, a director of Steel, Peech and Tozer, Limited, Sheffield, has experienced a nasty accident while motoring from Wales to London. Fortunately Mr. Steel sustained only a few bruises, and has now proceeded to Bournemouth, where he will probably remain for some months. Mr. Watson Smeeth, of Bradford, who was with Mr. Steel, was also only slightly injured.

Electric Steel Castings.*

By F. T. Snyder.

The following refers entirely to the practice of melting cold steel scrap with electricity in foundries. Such foundries usually pour less than ten tons of steel per day. Electric-steel castings have been on the market from a number of foundries for several years, and the use of electric furnaces for melting steel for small castings is rapidly spreading. The growth is due principally to the fact that steel in small quantities can, under usual conditions, be poured at a decidedly lower total cost from an electric furnace than from fuel-heated furnaces. A second reason for the growth of the practice is that the present quality of electric-steel castings is somewhat better than the quality poured from fuel-melted steel. It is practical with electric melting at a small increase of the usual melting cost to produce castings decidedly better in quality than those now on the market, as soon as the demand for such extra quality exists.

The improvement in quality of electric castings is primarily in the increased resistance to suddenly applied loads, making it permissible to use castings for parts subject to shock. The quality increase in this direction is large, electric castings standing two and three times the number of drop-hammer blows required to break fuel-melted steel of the same carbon contents in the same pattern. The tensile strength of electric steel is 5,000 to 10,000 lbs. higher than the fuel-melted steels for the same carbon. This is in part due to the higher specific gravity of the electric steel, which in turn comes from the smaller volume of microscopic blow-holes.

The cost of electric melting is lower than crucible melting principally because the electricity costs less than the crucibles, so that the competitive cost of fuel is immaterial. The cost of electric melting is lower than side-blow converter practice, because the steel scrap melted in the electric furnace costs so much less than the high-silicon pig-iron required for the converter that the difference more than pays for the electricity. The labour and refractory costs for both crucible furnace and converter are considerably higher than with an efficient electric furnace. The tonnage of the usual small-casting steel foundry is so small that a small open-hearth furnace can operate only part of the day, with resulting labour and refractory costs that are higher than for the same tonnage from a well-designed electric furnace.

In Table II. are given the general costs of electric steel in the Middle West of the United States for the usual range of tonnages for twenty-four and twelve-hour operations. Owing to the general practice of charging for electric power on a system of a primary demand charge per kilowatt plus a secondary consumption charge per kilowatt-hour, the cost of electricity per unit is much less for twenty-four-hour operation than for twelve-hour operation. A furnace loses heat during the night with twelve-hour operation, which has to be put in again when the furnace starts up in the morning. These two items make the cost of twenty-four-hour continuous electric melting decidedly lower than for twelve-hour operation. The figures given refer to the operation of a specific type of furnace of high average efficiency. The cost-per-ton table is based on the following charges :—

* Read at the Chicago Convention of the American Foundrymen's Association.

TABLE I.

	s.	d.	
Labour—			
Melter	20	0	per day.
Assistant melter	16	0	„ „
Helper	12	0	„ „
Labourer	8	0	„ „

	Basis.			
Electricity—Off Peak—	£	s.	d.	
Primary charge—				
First 100 kw.	3	0	0	per year
Rest	1	16	0	„
Secondary charge	3½ to 5d. per kw.-hr.			
Stock—				
Punchings	2	4	0	per 2,000 lbs.
Heads and gates	1	12	0	„ „
Pig-iron	2	8	0	„ „
Alloys—				
Ferro-silicon	8	0	0	
Ferro-manganese	10	0	0	

Interest, depreciation, supervision and overhead charges are not included, as they are about the same as for fuel-heated furnaces and differ widely from one foundry to another.

TABLE II.—*Costs per ton melted.*
(*Middle West U.S.A. Conditions. Public Service Electricity.*)

Hours run per day	12	12	12	24	24	24
Tons melted per day	4	8	12	5	10	20
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Labour	10 0	5 0	3 6	11 6	6 0	3 0
Electricity	41 0	32 6	30 6	29 0	26 0	21 6
Supplies	8 0	4 8	4 0	9 0	5 9	3 6
Conversion cost	59 0	42 2	38 0	49 6	37 9	28 0
Scrap	44 0	44 0	44 0	44 0	44 0	44 0
Ferro alloys	2 6	2 6	2 6	2 0	2 0	2 0
Melted metal cost	105 6	88 8	84 6	95 6	83 9	74 0

It is to be noted that the development in this electric steel melting for small foundries is in melting cold steel scrap rather than in using melted iron from a cupola. The principal reason for this is a matter of cost. It is usually cheaper to melt cold steel scrap than to use melted pig-iron. Melted cast iron contains 265 kw.-hours of electric heat per ton, but against this apparent saving there are certain items of additional expense, which considerably more than offset the saving. Pig-iron costs more than the steel scrap that an electric furnace can use. There is a higher metal loss. The pig-iron that is commercially available is relatively high in phosphorus and sulphur, and the time required for refining out these impurities adds to the cost. To reduce the carbon within a reasonable time from pig-iron values to the usual limits for steel castings requires the addition of iron oxide, usually iron ore. This leaves an oxidising slag and requires a more skilled melter to pour quiet steel from melted cast iron, than from cold steel scrap remelted.

TABLE III.—*Extra Cost.*
(*Melted cast iron—Cold steel scrap.*)
5 tons per 12 hours.

	s. d.	s. d.	s. d.
Cost of cupola melting		3 4	
Extra electric furnace time—			
Labour	3 9		
Electricity	10 8		
Supplies	4 2		
		18 7	
Stock—			
Pig-iron, 2,150 lbs. at 54s. per 2,000 lbs.	58 1		
Steel scrap, 2,050 lbs. at 44s. per 2,000 lbs.	47 0		
		11 1	
			33 0
Saving in electric power with melted cast iron, 265 kw-hours at 0.625d.			13 10
Extra cost, melted cast iron over cold steel scrap			19 2

Correspondence.

Cupola Construction.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—I have read the first article in the October issue of your journal, and read it again, to make sure I had not misunderstood it. I am a foundry hand of over 35 years' experience, nearly half of which I spent in the U.S.A., and this is the first time in all my experience that I have known of anyone arguing that the solid-bottom cupola was more convenient, or preferable, to the drop-bottom. In the first place, may I say that it is hardly fair to say, or claim, that one type is American and the other English, for as I look through your Journal I notice the advertisements of several makers of cupolas, but fail to find there an American firm advertising cupolas. What is more, there is not one who thinks it worth his while to illustrate a solid-bottom cupola. One might leave the point there, I think. If cupolas with receivers attached were referred to, I could understand the objections, but receivers are not mentioned in the article. Let us consider one or two of the points referred to, on the merits and demerits of the two types of cupolas.

In the first place, it is not quite correct to say that with a solid bottom one must melt all the iron before drawing the fire. It is a very common practice to draw the fire when there may still be a couple of charges in the cupola unmelted, and the writer, who has been both foreman and manager of foundries, can speak from personal experience. From this it will be understood that there is no prejudice on my part against the solid-bottom cupola. It is contended that making up the sand bottom in the drop-bottom cupola consumes a great deal of time; but it would be interesting to hear from persons accustomed to making up these sand bottoms, how much time was really necessary. I don't mean how much time is taken in this or that foundry for the work, but how much is necessary. The writer knows a London foundry where there is a small solid-bottom cupola in use, the bottom of which usually takes half a day to make up, with all the advantages a solid bottom may have; but he does not contend that is any argument for or against the cupola. Then, there is the reference to the moisture in the sand and the tendency to make the iron colder at first. I don't know whether the idea is based on theory or practice, but to the experienced it sounds rather humorous, when one comes to remember there is a rather fierce fire laying on the moist sand for some time prior to the melting of any iron; by the time metal gets there the moisture has greatly disappeared. The writer recently met with a foundry foreman, in a very large foundry in the country, where two drop-bottom cupolas were being put in by the proprietors, and the poor fellow was almost frightened into giving up his job; he was so afraid of an explosion because the drop-bottom doors had no vent holes bored in them. The cupolas, however, have been put into service, with the result that one ton of iron has been melted on one hundredweight of coke. This is where the rub comes in: it is often quoted in text books and by lecturers that from twelve to fourteen cwt. is as much as can be expected; but here is a case where it can be shown that with a cupola properly designed and properly handled after design, a great economical improvement can be recorded. Nor is this an isolated case; a few months ago the writer was called in as an independent expert, to test two cupolas of the same make, and, although the cupolas were run under the disadvantage of a smaller blower than desirable, owing to the fact that it was a great distance from the cupolas, there was no trouble experienced in getting eighteen cwt. of iron from one cwt. of coke. You will go a long way to find that result being obtained from a solid-bottom cupola.

Another point raised is that of the chance of the metal finding its way through the sand and out at the bottom; but may I ask, are solid bottoms foolproof from this complaint? Only last August Bank Holiday a very important London foundry had to have a new plate put in the front of the cupola (a solid bottom), through the metal finding its way through to the plate and melting its way out on to the floor, but had it been a drop-bottom the prop could have been pulled, and the cupola saved from a great deal of the damage done.

I would like to add that I am well convinced there is not enough interest taken in cupola practice by the ordinary foundry mechanic, the result being that though he may be a very good moulder, he is entirely ignorant about a cupola, and is thrown on the mercy of the furnaceman, who, in turn, is not as a rule much in advance of an unskilled labourer. The sooner it is recognised by the manager and proprietor that the cupola man should be one with some intelligence, as well as a strong arm, and that he is worthy of his hire when he has these qualities, the better it will be for all concerned. If I were to be made responsible for the most up-to-date equipment of a foundry for melting iron at the cheapest rate, which means the lowest consumption of coke, iron well mixed and at the right temperature, I should instal a drop-bottom cupola. This claim is based on an experience of over 20 years as foreman and manager, some in this country and some across the Atlantic.

Yours, etc.,

J. HILL.

London, November 14, 1913.

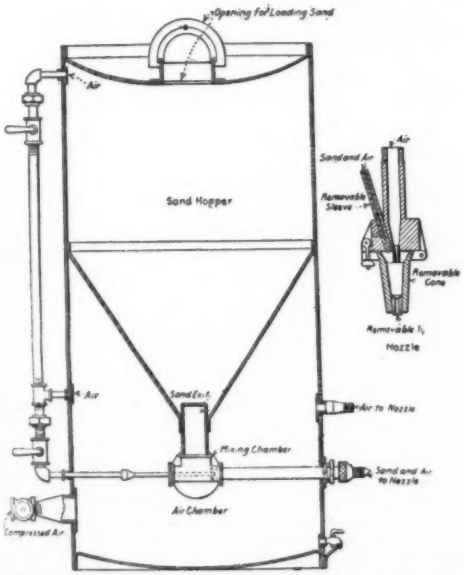
If our correspondent has never before known anyone to advocate the solid-bottom cupola in preference to the drop-bottom design, he cannot have followed very closely the discussions in British foundry circles during the last few years. On nearly every occasion when the subject has come up for discussion there have been strong partisans of both styles; and, as a recent example we may refer to the correspondence on page 670 of the same issue as that in which the editorial under criticism appears. As regards one type being American and the other English, the fact that most of the proprietary cupolas advertised have drop bottoms does not affect the case at all. The typical old English cupola certainly had a solid bottom, while the drop-bottom design was popular in America long before it was generally accepted here. As to the other points raised by our correspondent, we merely quoted the opinions which have been put forward from time to time; but, in view of the number of men who have raised the same objections to drop bottoms, it would appear that these are based on experience. It is not difficult, in defence of either type of furnace, to rake up cases where the other has failed or given trouble, and we could multiply the number of instances of defective solid-bottom cupolas many times in quoting cases of trouble with drop bottoms. As stated in our previous article, where the furnace is properly understood and worked with all due care, probably the drop bottom is the most economical in both labour and fuel, but to a comparatively slight degree. It is more a matter of the furnaceman's convenience and his acquaintance with the particular style of furnace. The adaptability of some furnacemen is not very great, and such are undoubtedly safer with the old style if they are ac-

customed to it; though this, of course, is no argument against the other style when properly managed. We must, however, protest against the suggestion of our correspondent to the effect that the high efficiency he mentions was due to the drop bottom. The suggestion is absurd on the face of it; for it presumes that if the bottom had not been dropped, but the furnace arranged instead for raking out, the efficiency would have been impaired. Cupola efficiency is dependent on the relative proportions and shape of the interior, the tuyere area, the pressure and quantity of blast, and the manner of charging; and obviously the ideal of all these can be made to apply equally well to either type. We have not the slightest desire to detract from the merits of the drop-bottom cupola; like our correspondent, we would probably instal it as being the most up-to-date, given a furnaceman who understood it. But at the same time, like its older rival, the drop-bottom type is not above criticism, and where its relative disadvantages appear sufficiently important, the foundryman is quite justified in expressing a preference for the solid-bottom type.

THE EDITOR.

Evans High-Pressure Sand-Blast System.

In an address before the Associated Foundry Foremen of Philadelphia recently, Mr. D. S. Ferris remarked that sand-blast machines had been in more or less successful use for many years, the first device



ARRANGEMENT OF EVANS SAND-BLAST APPARATUS AND DETAILS OF NOZZLE.

of the kind having been patented in or about the year 1870. This was followed by several others, all of which have been utilised chiefly for cleaning stone buildings, soft iron and brass castings. These machines are all of the single-hose type.

The Evans high-pressure sand-blast machine as applied to foundry work on both iron and steel castings is operated under a high pressure of from 90 to 100 lbs. and will maintain steadily this or any desired pressure. This is rendered practical by the use of a double hose connected at the nozzle, where the sand and the compressed air unite, each being brought to that point independently of the other so there is no loss of pressure from friction. The free air passes through a turbine high-velocity jet 3/16 in. in diameter. The turbine principle as applied to air is that which has been adopted in the machine. The compressed air being expanded in the nozzle through this turbine high-velocity jet, projects the sand from the end of the nozzle with a velocity of from 1,200 to 1,500 ft. per min. The discharge in cubic feet of free air at the following pressures will show its great efficiency and the fact that it uses not more than one-quarter of the air of any other single-hose machines :—

Discharge of Air Through 3/16-In. Turbine Jet.

Air. Cub. ft.	Pressure. lbs.	Power required. hp.
60	80	11.8
76.5	90	15
83.8	100	17.5

This great saving in air means a corresponding saving in horse-power. Again, the pressure is constantly maintained owing to the fact that the air which passes through the turbine jet, which is 3/16 in. in diameetr, can never vary. This jet will never increase in size as it is recessed back in the nozzle where the sand is forced through the sand and air hose into the mixing chamber or removable cone in the nozzle. The sand is then forced out through the tip of the nozzle by the pressure of air through the turbine jet, acquiring there a centrifugal or spiral motion which causes the sand to whirl and this motion going out through the tip of the nozzle at a high velocity strikes the object which is to be sand-blasted.

A New Pattern-Plate Material.

Under the name of "Platonite," a new composition for making pattern plates is being placed on the market by Murphy, Stedman & Company, Limited, 180, Gray's Inn Road, W.C. The material is supplied in the form of a powder accompanied by a liquid for mixing with it, the liquid being neither corrosive nor inflammable. When correctly proportioned the material sets, in the course of a few hours, into an extremely hard, stone-like compound, with an excellent face. We understand that the correct chemical combination is obtained only by using the right proportions of liquid and powder.

The materials after mixing are poured into a sand mould in the same way as pattern-plate metal. Before pouring, however, the mould, which should be of a very fine sand mixed with old machine oil and molasses, should be sprayed with a solution of paraffin in benzine or benzol (in the proportion of 1 to 9), and after the spray has evaporated it is advantageous to powder the mould with talc. This gives a coating which prevents the adhesion of the sand to the resulting pattern plate.

This composition is unlike cement in that it does not shrink or swell in setting. It gives a perfect delineation of the pattern, and if used as before outlined, the plate has a fine, hard surface. It is not necessary to varnish it, any moulding sand which adheres being merely brushed or scraped off.

D

Inventions.

Applications for Patents.

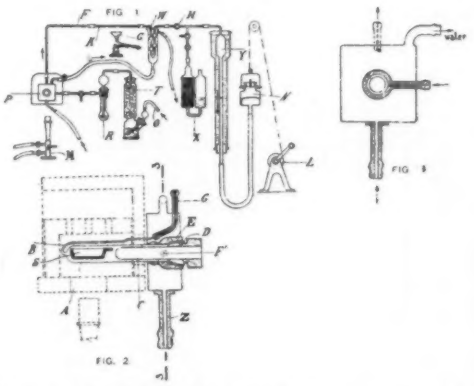
An Asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

23,719.*Casting ingots of metals and alloys. P. H. G. Durville
23,815.*Grates for furnaces. V. Lange.
23,982. Forming stripping plates for use with sand-moulding machines. John Harper & Company, Limited, and E. Evans.
24,080. Metal furnace. I. Hall.
24,081. Means for stirring molten metal in melting-pots. I. Hall.
24,164.*Furnace grates. (J. O. Garretsee and R. S. Patten, United States.)
24,239. Furnace linings. W. S. Rawson.
24,250 & 24,251. Metallic alloys. J. F. Duke.
24,297.*Treating cast-iron. J. E. Johnson, jun.
24,403. Furnaces. A. E. Swan and G. W. Parker.
24,467.*Furnaces. A. Hermans.
25,534. Heating furnaces. E. W. Gilbert.
24,799. Grinding-machines. Oliver Machinery Co., Ltd., and J. R. Appleby
24,816. Process for forming patterns and core-boxes for moulds for casting metals. D. Gordon and A. Hayes.
24,847.*Extraction of metal. H. Pape.
24,850.*Electric furnaces. I. Rennerfelt.
25,478. Crucible furnaces. A. C. Ionides, jun.
25,588.*Reversing regenerative furnaces. L. L. Knox.
25,678.*Manufacture of steel cylinders by fitting a cast-iron liner thereto. A. Girel.
25,799.*Transportable furnace for use in hardening, annealing, and tempering steel tools. (J. A. Blankertz, Germany.)

Abstracts of British Patent Specifications recently Accepted.

10,853 (1913). *Regenerative Open-hearth Furnaces.* T. B. Rogerson, Clyde Iron Works, Tollcross, Glasgow.—At present, with such furnaces, when the block is burnt, or gives way, it is usual to take the gas off and allow the furnace to cool down and then re-build the block with bricks. This procedure takes some time and, thereafter, the furnace has to be heated up again so that a loss of as much as for four days may take place before the furnace can be again used. The brickwork, through which the ports pass, is usually very massive, so as to prevent the ports giving way under the excessive heat, and sometimes hollow castings through which water can circulate are built in with the brickwork. In other cases, the whole block has been made removable, so that when burnt it can be lifted out by a crane and then replaced by another block, which is lowered into position. It has also been proposed in constructing a furnace, in the first instance to build the block of a plastic refractory material rammed or stamped down over lining pieces or pipes which form the flues or ports, the plastic material being such as to set hard before the lining pieces or pipes are burnt out or melt. The object of the present invention is to enable a burnt block to be repaired very rapidly and whilst the furnace is working. When the block between the air port and gas port is burnt or gives way to such an extent as to render it necessary to repair the same, there is inserted in the gas port, whilst the furnace is working, what is called a centre, this centre being more or less arched or tubular in shape. The centre is pushed into the gas port from the outside, a hole being provided for the purpose, and which is normally closed with bricks. When the centre is in place, it is quite easy for the workmen, by operating suitable working tools through the adjacent working door and the back opening, to re-build the block by piling on and about the centre a plastic mixture consisting of broken silica brick, silver sand, and silica clay, etc., this being done whilst the furnace is working. The mixture soon hardens under the great heat, whilst the centre itself burns away and leaves the newly-formed part of the block in position. A mixture consisting, by measure, of 50 per cent. broken silica brick, 20 per cent. of silver sand, and 30 per cent. of silica clay, answers very well. For finishing off the re-built block, a mixture composed of silver sand and silica clay may be employed, these ingredients being mixed together in or about equal proportions by measure. After the mixture has been acted upon by the gas for about half an hour or so, a little brown sand can be thrown on the re-built block so as to give a glazed surface finish.

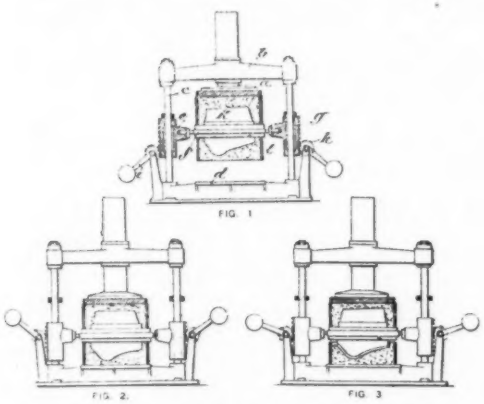
7,693 (1913). *Rapid Process of and Apparatus for Determining and Controlling the Carbon Content of Iron, Steel, etc.* E. Szàsz, Diòsgyör, Hungary.—Fig. 1 is a diagrammatic representation of the apparatus; Fig. 2 is a vertical section of the heating chamber; Fig. 3 is a cross-section taken on a plane at about the line 3—3 of Fig. 2. The combustion device is shown in elevation at P. Fig. 1, and in detail in Figs. 2 and 3. The lower and upper parts A and B of the combustion chamber are of platinum as is also the stopper C. The thickened body portion D of the stopper is supported by the thickened portion E of the retort shell. The water-cooled portions W, E and G of the apparatus are made of nickel. The material to be tested is placed in the boat S, which is placed in the combustion chamber. The chamber is closed by some suitable device, which will restrict the space of the chamber. The plug C is provided for this purpose. After the plug has been placed in the combustion chamber the entire apparatus is filled with



Apparatus for Determining the Carbon Content of Iron and Steel.

oxygen, which is supplied from some suitable source by a tube, from which it passes into and through the washing tower T, and the back pressure seal R to the combustion chamber by means of a suitable conduit leading to a coupling F^1. The combustion chamber illustrated is heated by means of a suitable gas burner M. Suction is produced by a mercury device N, operated by a winch L. When the metal has attained a temperature at which oxygen is violently absorbed, the cock H to the measuring burette Y is opened, which at first slowly sucks over a mixture of carbon dioxide and oxygen, and then an excess of the latter. The gases thus sucked over are, while flowing through the capillary tube F, caused to pass over glowing copper oxide in the tube K heated by the burner G and through the water cooler W, into which water is led through Z. In the apparatus illustrated the whole volume of gases may be about 200 c.c. The measuring burette will then be shut off. The operator removes carbon dioxide from the gas mixture by the absorption tube X and calculates its amount from the difference of the gas volume.

6,182 (1913). *Machines for Making Foundry Moulds.* R. Geiger, Kirchheim u/ Teck, Wurtemburg, Germany. —Fig. 1 shows a machine for making moulds before the commencement of the pressing; Fig. 2 shows the machine exerting pressure; and Fig. 3 shows the machine at the commencement of the return stroke. The press ram *a* passes through the cross member *b* of the machine, which is connected to the bed plate by two uprights *c* formed as guide rods. The bed plate supports the table *d*. Casings *e* are longitudinally displaceable along the guide rods *c*, and are constructed as bearings for the spindle of the pattern supporting frame *f*. These casings are also formed with racks *g* on their outside surfaces. Toothed pinions *h*, the spindles of which carry weighted levers *i*, engage with these racks *g*. The patterns *k* are secured in well known fashion upon the pattern frame *f* formed as a turnover plate, and the flasks *l* are fixed upon it. The bearing casings *e* and the pattern frame *f* slide down the guide bars *b*, upon the descent of the ram *a*, so that the weighted levers *i* are swung upwards. As soon as the bottom flask, the mould of which is completely



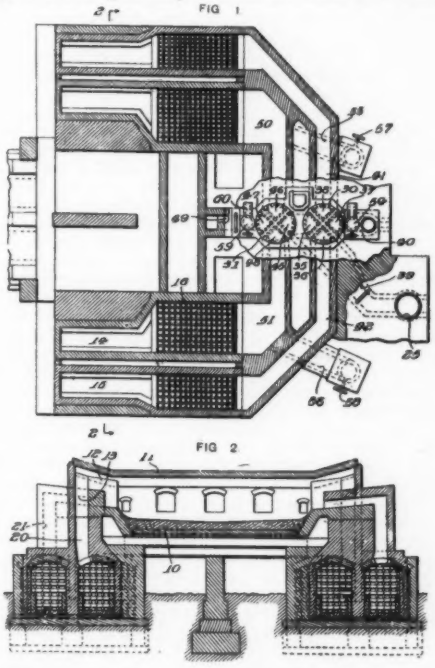
Foundry Moulding Machine, by Geiger.

pressed, rests upon the table *d* and the maximum pressure of the press is exerted, the securing wedges of the flask are knocked out and the gradual release of the pattern from the mould then begins, the pressure decreasing the return stroke of the ram, so that the pattern is loosened from the mould until it is withdrawn by the ascent of the pattern support, which is steadily pressel against the ram by means of the weighted levers. The gradual withdrawal of the pattern from the mould is effected by the action of the weighted levers, because their effect upon the pattern support increases as the pressure diminishes and takes place before the pattern support is actually drawn away from the mould.

12,991 (1912). *Furnaces of the Reversible Regenerative Type.* A. Reynolds, 117/119, Birkbeck Chambers, Southampton Buildings, London, W.C.—The claims of the patentee are for a gas-fired reversible regenerative furnace in which the air required for the complete combustion of the gas is supplied through a plurality of separate reversible air systems, and the relative quantities regulated by valves placed in a cool part of the system, so that the combustion of the gas can be effected in stages and the extent of the combustion accurately controlled in the several stages. One of the reversible air systems is designed to supply highly heated air to mix with the gas at the admission end of the working chamber of the furnace, and the other air system comparatively cold air to mix with the furnace gases after leaving the working chamber, completing their combustion and thereby raising the regenerators on that side of the furnace to a high but not excessive temperature.

23,536 (1912). *Heating by Gaseous Combustion and Furnaces therefor.* C. D. McCourt, 45, Braxted Park, Streatham Common, Surrey; and Bonecourt Surface Combustion, Limited, Parliament Mansions, Victoria Street, Westminster, London, S.W.—The patentee claims an enclosed furnace having one or more combustion beds of refractory material for the combustion of a mixture by the process known as surface combustion, wherein the heating of the charge is effected mainly by heat radiated from a large refractory surface suitably disposed for absorbing radiant energy from the combustion products. The combustion beds themselves constitute the primary radiating surface. The beds are so arranged with respect to a surface of refractory material within the furnace, that the heat radiated from the bed is reflected by the surface to the furnace charge. The combustion products are arranged to pass from the furnace cavity below the furnace floor or hearth and impart heat thereto. The combustion beds are disposed below the furnace hearth or floor levels, and the radiant heat therefrom is reflected on to the charge from the sides and/or roof of the furnace. The pipes or ducts whereby the gaseous mixture is conveyed to the combustion beds are jacketed and cooled by circulation of fluid within the jacket.

30,079 (1912). *Operation of Regenerative Furnaces Adapted more especially for the Manufacture of Steel.* N. E. Maccallum, 321, Gay Street, Phœnixville, U.S.A. —Fig. 1 is a fragmentary horizontal section of a furnace



Regenerative Furnace for the Manufacture of Steel.

constructed in accordance with this invention; Fig. 2 is a fragmentary vertical section of the same on the line 2—2 of Fig. 1. One embodiment of this invention comprises an open hearth steel furnace including the usual hearth 10 arched over by the roof 11. At each end of the furnace are two ports 12 and 13 opening into the space between the hearth 10 and its roof 11. These two ports are preferably arranged one above the other, and the upper port 12 is primarily intended to be used alternately for the inlet of air and for the outlet of exhaust gases, and the lower port 13 is primarily intended to be used alternately for the inlet of gaseous fuel and for the outlet of exhaust gases. Adjacent to

each end of the furnace and preferably in a plane below the arch 10 are two regenerators or checker chambers 14 and 15, the interior of each regenerator being preferably sub-divided into a plurality of passages by bricks or checkers 16. One regenerator 14, of each pair or set communicates with the coresponding air port 12 through an upwardly extending passage or flue 20 leading from the inner end of the regenerator to the port, and is intended primarily for regeneration or preheating of air. The other regenerator 15 of each pair communicates with the corresponding gas port 13 through an upwardly extending passage or flue 21, leading from the inner end of the latter regenerator to the gas port. A stack 25 is provided for the passage of exhaust gases from, and to create a suitable draught through, the furnace. For controlling the flow of gas, air and exhaust gases, through the furnace, two valves 30 and 31 are arranged between the two sets of regenerators. These valves may be of the usual reversing type or four-way construction, controlled by the rotation of a movable plug. One, 30, of these valves is provided with and controls four openings, 35, 36, 37 and 38, connected respectively to the stack 25, the source of gas supply, and the outer end of each of the two gas regenerators 15 by suitable conduits 39, 40, 41 and 42. The other, 31, of these valves, is also provided with four openings 45, 46, 47 and 48, connected respectively to the stack 25, the source of air supply, and the outer end of each air regenerator 14 by suitable conduits 39 49, 50 and 51. The conduit 40 between the reversing gas valve 30 and the source of gas supply is controlled by a three-way valve 54, having three openings connecting with the reversing gas valve, the source of gas, and the source of air supply respectively. This three-way valve 54 may be adjusted to cut off the supply of gas from the reversing gas valve 30 and to substitute a supply of air, or the reverse, or to close the conduit 40. For supplying gaseous fuel to the furnace through the air regenerators 14, the conduit 50 leading into the outer end of one of the air regenerators is provided with a branch gas conduit 55, the outer end of which communicates with the source of gas supply, and the conduit 51, leading into the outer end of the other air regenerator, is provided with a branch gas conduit 56, also communicating with the source of gas supply. These branch conduits 55 and 56 are controlled by valves 57 and 58 respectively. The air conduit 49, leading from the surrounding atmosphere to the reversing air valve 31, is also controlled by a valve 59, so that the supply of air may be cut off from the air reversing valve 31, when it is desired to utilise either of these regenerators for the passage of gas from either of the branch conduits 55 or 56. This valve 59 may be in the form of a three-way valve and be connected to the source of air supply or gaseous fuel by a branch conduit 60 so that the valve may be used to cut off the supply of air from the air reversing valve 31 and substitute a supply of gaseous fuel, or the reverse, or to close the conduit 49 and cut off both the supply of air and the supply of gas from the air reversing valve 31. When a three-way reversing valve is thus used, the branch gas conduits 55 and 56 may be omitted.

THE NORTH-EASTERN RAILWAY COMPANY, in co-operation with the River Tees Conservancy Commission, are projecting an extensive scheme for the development of th Port of Middlesbrough. The scheme comprises the construction of a new river wall and quay on the South Bank, about a mile in length, the object of the latter being to deal with traffic which cannot be conveniently dealt with in the Middlesbrough Docks. In addition to the deepening of the river and the construction of the quay, the company are seeking power to erect warehouses and buildings, and to construct all the necessary approach roads and connecting railways. One of the new lines will commence by a junction with the Darlington and Saltburn Railway at a point north-east of Grangetown Station, and will terminate south of Redcar wharf. Another line will commence at the south end of the company's West Marsh branch, near Sir B. Samuelson & Company's works, and will terminate by a junction with that branch.

Legal.

Canadian Agency, Limited v. Blair Open Hearth Furnace Company,

In an Appeal Court last month, an appeal from an order of Mr. Justice Warrington, brought by the Canadian Agency, Limited, was heard in the matter of the Blair Open Hearth Furnace Company, Limited. The appellants claimed the removal of their name from the register of the Blair Company, as the holders of 4,500 preference shares of £1 and 3,000 ordinary shares of 1s., and repayment to the Agency Company of £2,250 paid in respect of the preferred shares. The case for the plaintiffs in the Chancery motion was that they took the preference shares on the footing and on the understanding that certain guarantees by an American company would be attached to them, and in view of the fact that these guarantees had not been attached they claimed to be entitled to a rescission of their contract. They also complained that certain matters were omitted that should have been contained in the statement issued in lieu of prospectus. Mr. Justice Warrington said the ground on which the application was originally based was that the appellants had applied for the shares on a misrepresentation, consisting, they said, of a statement that interest at the rate of 7 per cent. on preference shares had been guaranteed by the Blair Furnace Company, an American company. His Lordship held that on that heading there had been no misrepresentation. The more serious contention was, however, that the allotment was void as being *ultra vires* of the company by reason of their non-compliance with Section 82 of the Companies (Consolidation) Act, 1908, which provided that a company not issuing a prospectus on or with reference to its formation (as in this case) should not allot any of its shares or debentures unless, before the first allotment, there had been filed with the Registrar of Companies a statement signed by the directors containing certain specified particulars. His Lordship held that in this case the company did file the signed statement before the first allotment of any shares. The contention was that certain statements were inaccurate. In that case penalties were provided by the Act, but if they were not wilfully inaccurate, that, in his opinion, dd not affect the allotment of shares, and he refused the motion, with costs. Against this decision the Canadian Agency appealed.

After arguments by counsel, their Lordships dismissed the appeal, with costs.

A CIRCULAR has been issued by the board of the Consolidated Diesel Engine Manufacturers, Limited, setting forth a proposed scheme of reconstruction. For the purpose of running the Ipswich works until they can pay their own way, in addition to the sum of £136,560 already disbursed on account of their erection, a further sum of between £70,000 and £80,000 is required. But the company is at present without sufficient funds, large advances having had to be made out of the company's funds for the purpose of completing contracts of the Diesel Engine Company, Limited (and intended to be recovered out of the proceeds of such contracts), which have become, unfortunately, to a large extent irrecoverable, owing to such contracts resulting in loss. The circular speaks well of the new works and the prospects if adequate working capital is secured. The directors think that the best method of obtaining the money required would be to reconstruct the company on a basis calculated to yield at least the required sum of cash after paying all expenses. If the scheme is adopted, it is intended to reorganise the board of directors and the general management of the company. A new company, to be called by the same name as the present company or by some similar name, is to be formed with a capital of £600,000, divided into 600,000 shares, each of £1. The present company's undertaking, assets and liabilities are to be made over to the new company in consideration of the issue of such 600,000 shares, each credited with the sum of 15s. as paid up thereon.

Trade Talk.

THE works of Cocker Bros., Limited, Nursery Street, Sheffield, have been seriously damaged by fire.

A FIRE broke out on November 9 at the works of Archibald Kenrick & Sons, Limited, ironfounders, of West Bromwich and Smethwick, the damage being heavy.

NOTICE has been issued of the release of Mr. S. W. Page as official receiver and liquidator of the Hurst Ironworks Company, Limited, of Wolverhampton.

KELVIN, BOTTOMLEY & BAIRD, LIMITED, of Glasgow, have established a branch office and showroom at Clayton Chambers, 61, Westgate Road, Newcastle-on-Tyne.

MANY of the Master Cutler's guests at the recent feast visited the River Don Works, Sheffield, of Vickers, Limited, and the East Hecla Works of Hadfields, Limited.

THE PALMER SHIPBUILDING AND IRON COMPANY, LIMITED, Jarrow, propose to blow out No. 1 blast furnace at Jarrow. This will leave two furnaces in blast out of five.

MANNING, WARDLE & COMPANY, LIMITED, of Leeds, have appointed Mr. W. B. Wilson, 19, West Parade, Newcastle-on-Tyne, as their agent for Newcastle and district.

THE last day for receiving proofs in connection with an intended dividend to be paid by Mr. A. H. Whatton, iron merchant, of Newcastle-under-Lyme, is December 5.

PROFESSOR J. O. ARNOLD, F.R.S., delivered a lecture at Sheffield University, on November 8, the first of the session, on "The Influence of Steel on the Advance of Civilisation."

MR. SYDNEY BUXTON has intimated to a deputation that the Board of Trade would be unable to recommend the Government officially to participate in the Lyons International Urban Exhibition.

MR. J. H. GLOVER, Central Buildings, Marygate, Wakefield, has been appointed trustee in connection with the affairs of Mr. John Gill, ironfounder, Queen's Foundry, Saw Yard, Wakefield.

MR. JUSTICE ASTBURY in the Chancery Division on Tuesday sanctioned the reduction of the capital of the British Westinghouse Electric and Manufacturing Company, Limited, from £1,875,000 to £1,150,000.

IN the Physics Theatre of the Armstrong College, on November 12, Dr. J. E. Stead, F.R.S., lectured under the auspices of the Society of Chemical Industry on "Some Alloys of Iron, Phosphorus and Copper."

MESSRS. CURRAN BROTHERS, of Cardiff, have been awarded a contract by H.M. War Office for a large number of furnaces to be erected on the "Curran" patent system of heating at the Royal Arsenal, Woolwich.

THE partnership which had for some time been carried on by J. G. Fiegehen and J. H. Brasher, under the style of the Bedford Engineering Co., at Bedford, as engineers and crane makers, was dissolved by the death of Mr. J. G. Fiegehen on May 4 last.

MESSRS. S. F. BIRKS, J. A. STEVENS, and H. G. STEVENS, carrying on busineses as steel manufacturers and merchants at 68, West Street, and 34, Edward Street, Sheffield, under the style of Birks, Stevens & Son, have dissolved partnership.

WALTER SLINGSBY & COMPANY, LIMITED, have erected new works, and on and after November 13 their address will be Woodhouse Road, Keighley. Their telephone number is as before, 367 Keighley, and the telegraphic address "Malleable." Keighley.

MESSRS. J. NOBLE AND J. H. CLEMITSON, carrying on business as engineers and millwrights, at Felling-on-Tyne under the style of John Noble & Company, have dissolved partnership. Mr. J. Noble will continue to carry on the business under the style of John Noble & Company.

ACCORDING to the text of the Great Eastern Railway Company's Bill, the directors propose to acquire the lands and buildings, docks, wharves, and premises situated between Bow Creek and the company's Woolwich branch railway and sidings, and known as the Thames Ironworks.

AT the meeting of the North-East Coast Institution of Engineers and Shipbuilders, held on November 28, in the Lecture Theatre of the Literary and Philosophical Society, Newcastle-on-Tyne, a paper was read by Mr. Georges Carels, entitled "The Present Position of the Diesel Engine, chiefly in Marine Propulsion."

THE 28th annual dinner of the Liverpool University Engineering Society has been held at the Exchange Station Hotel, Liverpool. Mr. L. H. F. Young (the president) presided, and those present included Professor Aspinall and Messrs. C. Sydney Jones, Edward Carey, and T. Wilkie.

THE BRIGHTSIDE FOUNDRY AND ENGINEERING COMPANY, LIMITED, have just secured the order from the London County Council for the steam generating plant, heating, ventilating, and hot water service installation for the new asylum to be built at Epsom. The amount of the contract is over £20,000.

MR. E. J. MARSH, A.M.I.E.E. (Electrical Superintendent of the Sheffield Corporation Tramways), lectured on November 24 to the Sheffield Society of Engineers and Metallurgists, at the Applied Science Department of Sheffield University, on "Protective Devices for Electric Power Supply." Mr. L. N. Ledingham presided.

A MEETING of the members of the West of Scotland Iron and Steel Institute was held in the rooms, 39, Elmbank Crescent, Glasgow, last month, Mr. Walter Dixon in the chair, when papers were read by Messrs. M. L. Simpson and James Kerr, Jun., on "Twenty-one Years' Progress in Steel Works" and "Malleable Iron" respectively.

IN the Chancery Division Mr. Justice Astbury has confirmed the reduction of capital of Martin, Earle & Company, Limited, from £245,000 to £146,000. It is proposed to write off £99,000, or 12s. in the £, from the ordinary shares, so that the capital henceforth will be £146,000, divided into 40,000 preference and 40,000 new preference shares of £1 and 165,000 shares of 8s.

AT a meeting of the members of the Institution of Engineers and Shipbuilders in Scotland in the Rankine Hall, Glasgow, under the chairmanship of Dr. R. T. Moore, the president, a discussion took place on Dr. C. H. Desch's paper on "Some Causes of Injury to Steel after Manufacture," and afterwards Mr. G. C. Webster subvnitted a paper on "Some Experiments on the Condensation of Steam."

THE partnership heretofore subsisting between Messrs. J. Hogg and T. Williamson, T. Hogg, and J. Hogg, the younger, carrying on business as brass founders, brass finishers, etc., at Bull Ring and at Lawson Street, North Shields, Tynemouth, under the style of Proud & Hogg, has been dissolved. Messrs. J. Hogg, T. Hogg, and J. Hogg, the younger, will continue the business under the style of James Hogg & Sons.

THE partnership heretofore subsisting between the late Mr. T. Croft and Mr. J. Ewan, as engineers and agricultural implement manufacturers, at 29, North Road, and the New Market Entrance, both in Lancaster, and at Chapel Yard, Preston, under the style of Croft & Ewan, has, by reason of the death of Mr. T. Croft, been dissolved, and the business will henceforth be carried on by Mr. J. Ewan under the same style.

G. P. WINCOTT, LIMITED, of Attercliffe Road, Sheffield, have received a repeat order from the Bynea Steel Works, Limited, of Bynea, near Llanelly, for one double continuous ingot re-heating furnace, also for two forging furnaces with flues, chimney, and steam hammers foundation from George Turton, Platts & Company, Limited, of Sheffield, and for one file annealing furnace from Messrs. J. & F. C. Wild, of Sheffield.

THE partnership heretofore subsisting between Messrs. R. Lund and F. C. Polden, who carried on business as electrical and mechanical engineers, at 78-80, Queen Victoria Street, London, E.C., under the style of Lund Bros. & Company, has been dissolved. Mr. R. Lund will continue to carry on the business under the style of Lund Bros. & Company, at the same address. Mr. F. C. Polden will carry on business under the style of Francis Polden & Company, at 56, Cannon Street, London, E.C.

A MANCHESTER section of the Junior Institution of Engineers was inaugurated at a meeting held at the Victoria Hotel, Manchester, on October 31. Mr. W. A. Tookey, vice-chairman of the Institution, presided, and was supported by Mr. S. Bylander, chairman, and members of the Council. A large number of engineers signified their intention to join the new branch, and the following were elected officers:—Mr. C. H. Prichard, chairman; Mr. M. Hird, vice-chairman; and Mr. F. G. Hatch, hon. secretary.

A MEETING of the creditors of Joseph Green and Nephew, Limited, Globe Ironworks, Crown Point Road, Leeds, took place on November 14. The statement of affairs showed liabilities amounting to £2,610 5s. The assets were estimated to produce £2,894 3s. 10d. There were preferential claims, including interest on debentures and costs, amounting to £1,381 3s., there being a net deficiency on the estate of £1,097 4s. 2d. The deficiency it was explained was due to loss on trading, and depreciation from the assets as disclosed in the statement of affairs. No committee of inspection was appointed.

THE directors of the Engineers' Club, of Manchester, gave an inaugural luncheon in the Club premises, Bridgewater Buildings, Albert Square, recently. The company, which numbered about fifty, included Sir Charles Behrens, the Deputy Lord Mayor of Manchester, Mr. E. H. Langdon, President of the Manchester Chamber of Commerce, Dr. Edward Hopkinson, Dr. G. J. Fowler, and the representatives of the principal societies of the country. Apologies for their inability to be present were received from Sir William Mather and Messrs. Frank Nasmith, Hans Renold, W. T. Stubbs, and F. S. Sells. Mr. Daniel Adamson was in the chair.

MESSRS. JAMES BUCHANAN & SON are completing a considerable addition to their works in Brasenose Road, Kirkdale, Liverpool. Hitherto the pattern and the general stores have been housed in independent buildings in other portions of the road. The new pattern stores general stores, etc., will be contained in a three-storey building, which is in course of erection, adjoining the works and which fronts on and will have a gateway entrance into Syren Street. At the rear of this building a light foundry has been laid down, designed to relieve the congestion in the old foundry, which will now be solely devoted to the production of heavy castings.

THE directors of the New Dunderland Company, Limited, in offering shareholders their proportion of shares in the New Dunderland Company, Limited, in accordance with the scheme recently approved by the various meetings and sanctioned by the Court, announce that the new company has secured an option to acquire a controlling interest in the West Fjord Iron Ore Company, Limited, and, through it, in the Aktiebolaget Ofotens Malmfält, a Swedish company owning large and developed iron ore properties at Bogen-i-Ofoten, near Narvik, Norway, which has a paid-up capital of 3,000,000 kr., with a debenture charge of 1,800,000 kr. The issued capital of the West Fjord Iron Ore Company, Limited, is £220,000.

THE members of the Institute of Marine Engineers held their twenty-third annual dinner in London on November 21, Mr. T. L. Devitt, the president, being in the chair. Among those present were Sir Archibald Denny, Mr. G. Marconi, Sir J. Fortescue Flannery, Captain A. W. Clarke (Trinity House), Messrs. James Adamson (hon. secretary), W. L. Hichens, W. Rowan Thomson, John Dewrance, George J. Carter, C. Wray Palliser, George L. King, Andrew Laing, Robt. Corry, George T. Henderson, C. F. Redman (Lloyd's Register), James Bain, Joseph Hallett (Chairman of Council), Summers Hunter, Robt. Leslie, J. H. Silley, and Dr. R. T. Moore (President of the Institute of Engineers and Shipbuilders in Scotland).

IN the Chancery Division, Mr. Justice Sargeant had before him the application of the Countess Morner v. Heskett Steel Castings (British), Limited. Mr. J. W. H. Holmes said he was asking for the appointment of a receiver of the defendant company in a debenture holders' action. The principal moneys became due on default of payment of interest, which was now three months overdue. The company had ceased to carry on business, and proceedings against the company for the recovery of money which it was unable to pay were pending in the King's Bench Division that morning. Mr. Farwell, for the company, did not oppose. His Lordship gave the usual judgment in a debenture holder's action, appointing Mr. Goodrich, chartered accountant, as receiver.

THE fourth Newmarch lecture on "The National Output, as Shown by the First Census of Production," was delivered last month, at the University College, by Mr S. W. Flux, M.A., Director of the Census, who discussed the position of the British iron and steel trade with that of the textile industries. The lecturer produced an interesting figure for statistical purpose by the employment, in a series of calculations, of what he described as the "hypothetical equivalent male unit," six representing the male, three the female, and two the juvenile worker. On this basis, he showed £120 would be the net output per head for the iron and steel trades. The actual net output figure given in the final report on the census was £115 for iron and steel smelting, rolling, and founding, in which there was little female and juvenile labour.

AT Salt End, on the River Humber, about 21 miles from Spurn Point, a large undertaking is rapidly approaching completion, which is expected to play an important part in the supply of oil to this country in the future This undertaking is the construction by the North-Eastern Railway Company of an oil distributing depôt for the North of England. The primary object of the undertaking is to import oil of all kinds from various sources, and distribute it to different parts of England, particularly the Northern Counties and the Midlands. More than 20 tanks for the storage of different kinds of oil are in course of construction, and some of these tanks have a storage capacity of 525,000 gallons each. The depôt, which, when completed, will comprise 187 acres, will be joined up to the new Joint Dock and the whole of the other docks at Hull by railway sidings, and oil can be shipped from the quaysides there.

AN influential committee has been formed with a view to asking the Government to reconsider their decision regarding participation in the Panama-Pacific Exposition at San Francisco in 1915. We understand that the committee are likely to ask the Government to receive a deputation. The committee includes such well-known names as Lord Aberconway, Lord Cowdray, the Right Hon. Sir William Mather, Sir Robert Balfour, M.P., Sir Charles S. Henry, M.P., Mr. David Davies, M.P., Sir Alexander Henderson, M.P., Mr. J. S. Harmood-Banner, M.P. (Lord Mayor of Liverpool), Sir J. Fortescue-Flannery, M.P., Colonel Sir Charles Allen, Sir Robert Hadfield, Sir Marcus Samuel, Mr. D. A. Thomas, the Marquis of Graham, Sir Albert K. Rollit, Lord Airedale, Mr. J. Allen Baker, M.P., and Mr. G. B. Hunter. The committee has opened temporary headquarters at Trafalgar Buildings, Trafalgar Square, London, and the hon. secretary, Mr. W. A. M. Goode, will be glad to give any information to manufacturers interested in the movement.

THE FARADAY SOCIETY held a discussion on November 12 in the the rooms of the Chemical Society on "The Passivity of Metals." Professor Donnan taking the chair in the absence of Sir Robert Hadfield. The discussion, to which papers were contributed by several foreign men of science, was opened by Dr. George Senter. Dr. Grube (Dresden) took as his subject "Andoic and Cathodic Retardation Phenomena and their Bearing on the Theory of Passivity." Dr. D. Reichinstein described in his paper several of the most recent experiments on the subject. Mr. H. Stanley Allen read a paper on "The Photo-Electric Behaviour of Iron and the Theory of Passivity." Professor Gerhard C. Schmidt (Münster) and Herr W. Rathert brought forward notes of several experiments on the subject. Professor Max Le Blanc (Leipzig) contended that passivity phenomena were to be traced to those of reaction velocity. Professor E. P. Schoch (Texas) contributed a paper on "The Mechanism of Anodic Reactions and the Behaviour of Iron and Nickel Anodes." A general discussion folllowed.

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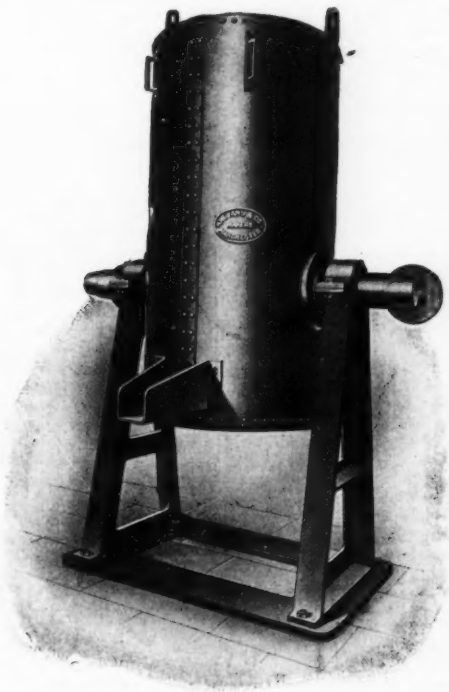

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Deaths.

THE death is reported at the age of 68 years of Mr. W. N. Bakewell, M.Inst.C.E., of Keswick.

THE death took place on November 4 of Mr. Henry Thomas, ironfounder, of Llanelly, at the age of 81 years.

MR. JOHN HUTCHINSON SHARP, a director of the North British Locomotive Company, Limited, died at Glasgow on November 7.

THE death has occurred, at the age of 80 years, at Glen Lodge, Richmond Park Road, Bournemouth, of Mr. John Morris, sen., founder of the firm of John Morris & Sons, Limited, Salford Fire Engine Works, Manchester.

The death took place, on November 2, of Mr. J. W. Sankey, at the age of 58 years. He was chairman of the directors of Joseph Sankey & Sons, Limited, of the Albert Street, Bankfield and Manor Works, Bilston, and the Hadley Castle Works, Shropshire.

MR. H. M. BIGGLESTON, head of the firm of H. M. Biggleston & Sons, iron founders and engineers, died at Canterbury, on November 11, in his 77th year. The firm supplied much of the ironwork used in the construction of the Kentish railway systems.

THE death has occurred suddenly in London of Mr. David Wyllie Abernethy, a partner in the well-known firm of James Abernethy & Company, Ferryhill Foundry, Aberdeen. Mr. Abernethy, who was about 66 years of age, took little part in the public life of his native Aberdeen, but was held in high regard in business circles.

THE death occurred recently in Germany, of Herr Fritz Asthöwer, one of the oldest figures in the German iron and steel industry. The deceased gentleman was born at Cologne in 1835. After considerable experience he founded, in 1876, the firm of Fritz Asthöwer & Company, which was eventually absorbed by the firm of Krupps in 1886, Herr Asthöwer himself entering their directorate.

WE regret to announce the death of Sir William Henry Bailey, which occurred on November 22, in London, at the age of 75. Sir William was born in Salford in 1838. He was the son of Mr. John Bailey, who in early life had been at the head of the experimental department of the engineering works of Messrs. Sharp & Roberts. This Mr. John Bailey, who was also an inventor of great fertility and resource, began business on his own account, and founded the firm in Salford known as W. H. Bailey & Company, Limited. Sir William Bailey, who was educated at the Manchester Grammar School, began his business career as an apprentice in his father's machine shop. The business was then, however, only in its infancy. Its growth was materially fostered by the inventions of Sir William, who inherited his father's talents, and became as years went on the patentee of innumerable new devices. In 1866 Mr. John Bailey retired from business, leaving his son in sole management and proprietorship of the Albion Works.

THE death took place on November 21 of Mr. James Howden, chairman of the firm of James Howden & Company, Limited, engineers and boilermakers, Glasgow. Mr. Howden, who was in his 82nd year, was educated at the parish school at Prestonpans, and at the neighbouring village of Tranent. In 1854 Mr. Howden, then in his 22nd year, started in business for himself. About that time he designed machinery for rivet-making, and sold the patent to a Birmingham firm. In 1862, he purchased ground in Scotland Street and founded the firm of James Howden & Company. It is, however, by reason of his system of hot-air forced-draught that Mr. Howden's name is best known. Early in 1862 he began a long series of experiments to demonstrate to his own satisfaction the practicability of his theories on this subject. From these experiments he devised the arrangement now known throughout the world as the Howden hot-air forced-draught system. Mr. Howden was the last survivor of the original membership of the Institution of Engineers and Shipbuilders in Scotland, which was founded in 1857. He was also a member of the Institution of Civil Engineers, and a member of the Institution of Naval Architects.

Personal.

MR. J. C BRIDGE has been appointed an Inspector of Factories and Workshops.

SIR HUGH BELL, BART., has been re-elected chairman of the Tees Conservancy Commission for the ensuing twelve months.

MR. DAVID BUCHANAN, MR. WILLIAM BARRETT, and MR. H. A. HEPBURN have been appointed Inspectors of Factories and Workshops.

THE late Mr. W. Lowe, a director of Dean & Lowe, Limited, left estate valued at £18,032 gross and £15,265 net.

MR. CHARLES CARELS has resigned his seat on the board of the Consolidated Diesel Engine Manufacturers, Limited, in consequence of ill-health.

THE late Sir Alfred Apperley, chairman of the Stroud Metal Company, Limited, left estate of the gross value of £43,384, of which £26,162 is net personalty.

THE late Mr. A. M. Melvin, managing director of T. Melvin & Sons, Limited, of the St. Rollox Ironworks, Glasgow, left personal estate of the total value of £5,394.

WITH reference to the announcement that Lord Pirrie is shortly retiring from the chairmanship of Harland & Wolff, Limited, his lordship states that the report is unfounded.

MR. W. E. NOON, for ten years foundry manager for the Albert Foundry Company, Halifax, has left to take up a similar position with Messrs. Kemmell Bros., Thornaby-on-Tees.

MR. C. O. PIERCY, of the chief goods manager's department, Midland Railway, Derby, has been appointed chief of the rates department to Cammell, Laird & Company, Limited, Sheffield.

A PRESENTATION has been made to Mr. T. H. Byrom, F.I.C., on his severing his connection with the Wigan Coal and Iron Company, Limited, as chief chemist, to take up an appointment in London.

THE late Mr. A. J. Maclean MacMaster, of Messrs. Campbell, MacMaster & Company, engineers and steel and iron merchants, of Suffolk House, Laurence Pountney Hill, London, E.C., left estate of the gross value of £3,925, of which £3,636 is net personalty.

MR. GEORGE STRACHAN, the secretary of the Fairfield Shipbuilding and Engineering Company, Limited, has been elected a director in place of Colonel Paget Mosley, who has resigned owing to failing health. Mr. Strachan will continue his secretarial duties.

SEVERAL changes have lately taken place on the directorate of Baldwins, Limited. As far back as December last Mr. Isaac Butler resigned his directorship, and his two sons, Mr. A. I. R. Butler and Mr. Hubert Butler, have now also severed their connection with the firm.

PROFESSOR BARR, who is retiring from the Chair of Engineering in the University of Glasgow, has been entertained at dinner in the Randolph Hall of the University. In the absence of the Principal, Sir Donald MacAlister, Lord Provost D. M. Stevenson presided, and the attendance was representative not only of educational circles, but also of the shipbuilding and engineering industries of the city.

THE former students of Sir Henry Roscoe decided some time back to commemorate the celebration of his eightieth birthday in January, 1913, by presenting his bust to the Chemical Society of London. With this object in view a Committee was formed, of which Sir Edward Thorpe has acted as chairman. The formal presentation of the bust to the Chemical Society took place last month at the Society's rooms, when amongst those present, in addition to Sir Henry Roscoe, were Sir Edward Thorpe, Sir Archibald Geikie, president of the Royal Society; Professor W. H. Perkin, president of the Chemical Society; Professor H. B. Dixon, Sir William Tilden, Sir Thomas Barlow, Sir J. Rose Bradford, Sir Henry Miers, Professor Arthur Schuster, Professor H. E. Armstrong, Professor Percy Frankland, Professor A. W. Crossley, Professor Arthur Harden, and Dr. Charles A. Keane, Secretary to the Committee.

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HULL

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FOUNDRY PLANT.

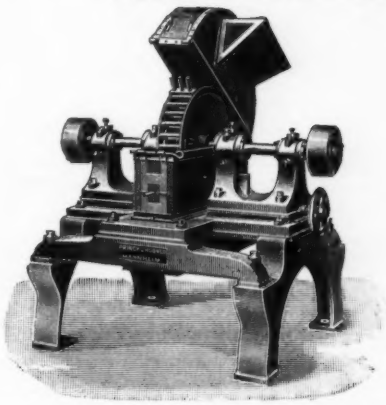
SAND MIXERS. ROLL MILLS.

DISINTEGRATORS.

BRINCK & HÜBNER,

Mannheim, Germany.

Agents - SCHNAKENBECK & Co.,
40, Old Broad Street, LONDON, E.C.



ELDERS FOUNDRY COKE

AS SUPPLIED TO THE

BRITISH

ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Elders Collieries, Ltd., Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

METALS.	End Nov., 1913.	End Nov., 1912.
IRON—Scotch pig warrants ton	..... *55/3	..... *73/10½
—Middlesbro' warrants ton	..... 49/4½	..... 67/8½
—W.C. Mixed Bessemer ton	..... 67/0	..... 86/6
—Stock, Middlesbrough tons	 151,625	 252,679
COPPER—Chili bars G.M.B. ton	..... £66 17 6	.... £76 12 6
—Stock, Europe and afloat tons	 25,913	 43,552
TIN—English ingots.. ton	.....£183 0 0	....£220 10 0
—Straits .. .. ton	.....£180 10 0	....£226 10 0
—Stock, London, Holland U.S.A., and afloat.. tons	..... —	..... —
LEAD—English pig .. ton	.....£18 15 0	.... £18 7 6
SPELTER—Ord. Silesian ton	.....£20 12 6	.... £26 0 0
QUICKSILVER (75lb.).. bottle	..... £7 10 0	.... £7 12 6
ANTIMONY—Regulus ton	£28 0 0 £30 0 0	£39 0 0 £40 0 0
ALUMINIUM—Ingot .. ton	£81 0 0 £85 0 0	.... £85 0 0

* Settlement price.

CASTINGS.

In the Cleveland district the following are the nominal rates current for castings :—

	£ s. d.	£ s. d.
Columns (plain)..	7 7 6 to	7 12 6
Pipes, 1¼ to 2½ in.	6 7 6 to	6 12 6
,, 3 to 4 in.	6 0 0 to	6 2 6
,, 5 to 8 in.	5 15 0 to	5 17 6
,, 10 to 16 in.	5 17 6 to	—
,, 18 to 24 in.	5 17 6 to	—
Chairs	4 14 0 to	4 15 0
Floor plates (open sand)	3 10 0 to	3 12 6

SCRAP.

The quotations for scrap, subject to market fluctuations, are as follows : Heavy wrought (mixed), £2 7s. 6d.; light wrought, £1 5s. 0d.; heavy cast, £2 12s. 6d.; all per ton, f.o.b., London. Copper (clean), £62 10s. 0d.; brass (clean), £40 10s. 0d.; lead (usual draft), £17 5s. 0d.; zinc, £16 5s. 0d.; all per ton delivered merchant's yards.

New Companies.

MIRIS STEEL COMPANY, LIMITED.—Capital £100 in £1 shares.

B. DOUGLAS & COMPANY, LIMITED.—Capital £100,000 in £10 shares, to carry on the business of iron merchants.

LIGHT STEEL TUBULAR WHEELS, LIMITED.—Capital £9,000 in £1 shares. Registered office: 33, Amberley House, Norfolk Street, W.C.

LONDON DIE CASTING FOUNDRY, LIMITED.—Capital £3,000 in £1 shares. Registered office: 90 and 92, Banners Street, St. Luke's, E.C.

DICKINSON ELECTRICAL MANUFACTURING COMPANY, LIMITED.—Capital £2,000 in £1 shares. Registered offices; 85, Broadway, Bexley Heath.

BROADBENT & HEY, LIMITED.—Capital £2,000 in £1 shares, to carry on the business of ironfounders. Registered office: Flowery Field Iron Works, Hyde, Cheshire.

KIRKLAND STEEL FOUNDRY, LIMITED.—Capital £42,000 in 40,000 ordinary shares of £1 and 40,000 deferred shares of 1s. Registered office: 28, Victoria Street, Westminster, S.W.

HARVEY & MORRIS, LIMITED.—Capital £200 in £1 shares, to carry on the business of iron and brass founders and casters, etc. Registered office: 10, Union Passage, Birmingham.

CHARLES WILSON, LIMITED.—Capital £2,000 in £1 shares, to take over the business of iron and brass-founder carried on at Atlas Foundry, Staveley Road, Sheffield, as Charles Wilson.

MURTON & VARLEY, LIMITED.—Capital £20,000 in £1 shares, to take over the business of engineers carried on at the Anchor Works and Victoria Works, Keighley, as Murton & Varley. Registered office: Anchor Works, Longcroft, Keighley, Yorks.

CHARLES MARTIN & COMPANY, LIMITED.—Capital £10,000 in £1 shares (3,000 preference), to take over the business of an engineering and gearing manufacturer carried on by Mr. C. Martin at Kelvin Works, Gateshead. The first directors are Mr. Martin and Mr. J. G. Cranston.

DEREHAM IRONWORKS, LIMITED.—Capital £6,000 in £1 shares (2,000 six per cent. cumulative preference), to take over the businesses (1) carried on at Cowper Road, East Dereham, Norfolk, as John Roots & Company, and (2) carried on at Wellington Road, East Dereham, as T. L. Barker.

FOSTER, BLACKETT & WILSON, LIMITED.—Capital £50,000 in £1 shares (26,000 8 per cent. cumulative preference to acquire the business formerly carried on by Foster, Blackett & Wilson, Limited, at Newcastle-on-Tyne, Hebburn, and elsewhere, as lead merchants and refiners, desilverizers, etc.

MIDLAND FOUNDRIES, LIMITED.—Capital £1,000 in £1 shares, to carry on the business of iron and brass founders, etc. The subscribers are: W. Locker, 42, Belgrave Road, Birmingham, manufacturer; L. Wheatcroft, 43, Cannon Street, Birmingham. Registered office: Newton Chambers, 43, Cannon Street, Birmingham.

ROWLAND HODGES, LIMITED.—Capital £12,000 in £1 shares, to take over the business of a brassfounder and hinge and lock furniture manufacturer, carried on at Frederick Works Brearley Street, Birmingham, as Rowland Hodges. The first directors are R. Hodges and J. L. Hodges (both permanent). Registered office: Frederick Works, Brearley Street, Birmingham.

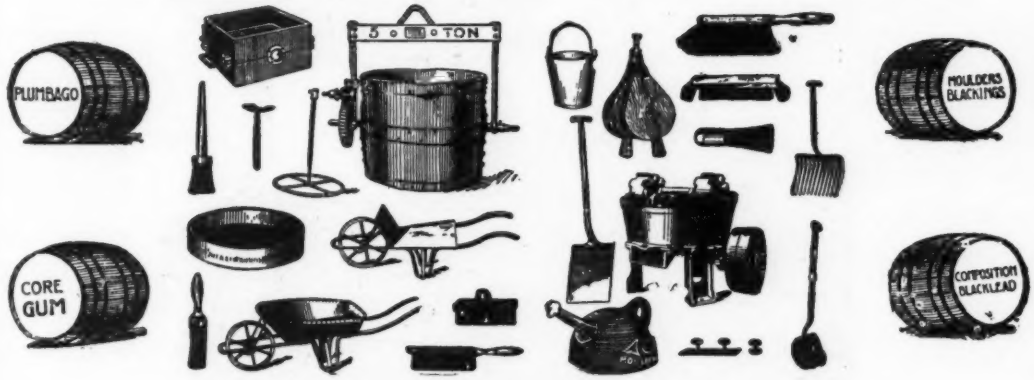
C. W. ROBINSON & COMPANY, LIMITED.—Capital £10,000 in £1 shares, to take over the business of manufacturers of iron and steel of Charles Walter Robinson at Forth Bridge Steel Works, Polmont Station, under the name of C. W. Robinson & Company. Private company. Subscribers: A. W. Barclay, engineer, 122, Wellington Street, Glasgow; E. W. Campbell, steelfounder, Lochcote House, Linlithgow; M. W. Henderson, Linlithgow.

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,
FIRE CLAY.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
STEEL MOULDERS' COMPOSITION, SILICA CEMENT.
J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.
Telegrams: "LOWOOD, DEEPCAR."

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



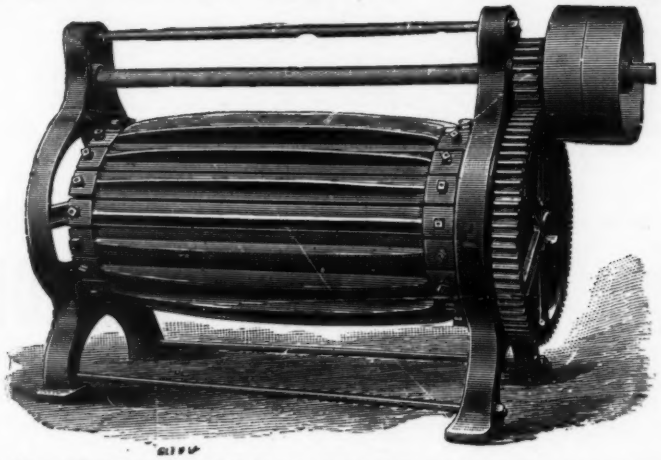
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



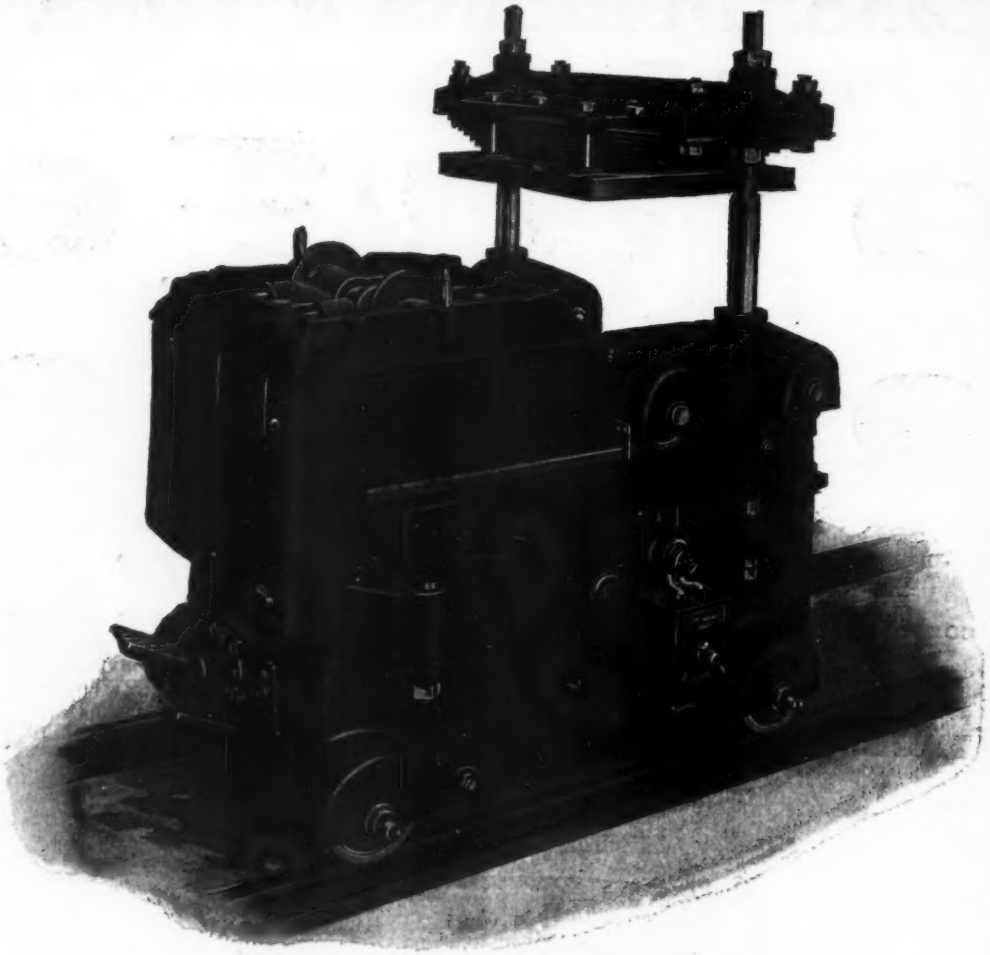
These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

USE YOUR ELECTRIC POWER FOR MOULDING.



THE NEW PORTABLE ELECTRICALLY-OPERATED MOULDING MACHINE.

SPEED. ACCURACY. DURABILITY.

We invite you to call and see the machine in operation, or if you will send us Blue Prints or Sample Castings we shall be pleased to quote for most suitable machines with full particulars, without any obligation on your part to purchase.

THE LONDON EMERY WORKS Co., PARK WORKS,

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Nearest Passenger Station, Park, G.E.R. Telephone: Tottenham 158.

THE BUYER'S GUIDE

Addresses and further information will be found by reference to the Firm's Advertisement.

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London Emery Works.
Murphy, Stedman & Co., Ltd.

Air Compressors.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Electrically Driven).
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors(Steam).
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Belt).
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Aluminium.
British Aluminium Co., Ltd.

Annealing.
Evans, J., & Co.
Phillips, J. W. & C. J.

Ash Crushing and Washing Machines.
Evans, J., & Co.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Barrels (Tumbling).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Hall, Charles, & Co.
Hooker, Peter, Ltd
London Emery Works Co.
Marshall, H. P., & Co.
Phillips, J. W. & C. J.
Standard Sand-Blast Machine Co., Ltd.
Tilghman's Patent Sand Blast Co., Ltd.

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Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles, & Co.

Bellows.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Durrans, Jas., & Sons.
Hall, Charles, & Co.
Olsen, Wm.

Blacklead.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Olsen, Wm.
Walker, I. & I
Wilkinson & Co., Thos., Ltd.

Blowers.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davis, T., & Son.
Dempster, R. & J., Ltd.
Evans, J., & Co.
Keith, J., & Blackman Co.,Ld.
London Emery Works Co.

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Phillips, J. W. & C. J.
Samuelson & Co., Ltd.
Thwaites Bros., Ltd.

Buffing and Polishing Machines.
London Emery Works Co.

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Durrans, J., & Sons.
Evans, J., & Co.
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

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Aerators, Ltd.

Cement.
Dyson, J. & J.
Evans, J., & Co.
Hall, Charles, & Co.
Hawkins & Co., W T.
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Lowood. J. Grayson, & Co., Ld.
Major, Robinson & Co., Ltd.
Marshall & Co., Horace P.
Metalline Cement Co
Olsen, Wm.
Rudd & Owen.
Silent Machine and Eng. Co.

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Durrans, J., & Sons.
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Marshall & Co., Horace P.
Motherwell, Wm., & Co.
Olsen, Wm.
Wilkinson, T., & Co., Ltd.

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Evans, J., & Co.
Hall, Charles, & Co.
Mansergh, T. E.
Walker, I. & I.

Charging Platforms.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T., & Son.
Evans, J., & Co.
Marshall & Co., Horace P.
Thwaites Bros., Ltd.

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Evans, J., & Co.
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Mansergh, T. E.
Olsen, Wm.
Walker, I. & I
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Elders Navigation Collieries.
Murphy, Stedman & Co., Ltd.

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Evans, J., & Co.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

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Olsen, Wm.

Core Compounds.
Cumming, Wm., & Co., Ltd.
Durrans, J., & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Olsen, Wm.
Wilkinson Thos., & Co.

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Hall, Charles, & Co
Olsen, Wm.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd.

Core Making Machines.
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Core Ropes.
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Wilkinson, T., & Co.

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Olsen, Wm.

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Ward, T. W., Ltd.

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Murphy, Stedman & Co., Ltd.
Olsen, Wm.

Crucible Furnaces.
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Evans, J., & Co.

Crucible Furnaces (Lift-out).
Alldays & Onions Pneumatic Eng. Co., Ltd.
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Marshall, H. P. & Co.
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.

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Marshall & Co., Horace P

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London Emery Works Co.

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London Emery Works Co.

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Olsen, Wm.

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McNeil, Chas.
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Thwaites Bros., Ltd.

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Marshall & Co., Horace P.
Phillips, J. W. & C. J.

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Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Furnaces (Melting).
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Ground Gannister.
Durrans, J., & Sons.
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Evans, J., & Co.
Lowood, J. Grayson, & Co.
Walker, I. & I.

Grinding Machines and Tools.
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London Emery Works Co.

Hammers (Steam).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Thwaites Bros., Ltd.

Hay Band Spinning Machines.
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Marshall & Co., Horace P.

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Phillips, J. W. & C. J.
Thwaites Bros., Ltd.

Loam and Sand Mills.
Davies, T., & Son.
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Murphy, Stedman & Co., Ltd.

Magnetic Separators.
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Melting Furnaces (Oil Fired).
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Murphy, Stedman & Co., Ltd.
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Buckley & Taylor, Ltd.
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Phillips, J. W. & C. J.
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Samuelson & Co., Ltd.
Stewart, Duncan & Co., Ltd.
Universal System of Machine Moulding and Machinery Co., Ltd.
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Murphy, Stedman & Co., Ltd.
Phillips, J. W. & C. J.

Pattern Letters.
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Pig Breakers.
Evans, J., & Co.
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Pig-iron.
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Griffin & Co., C.

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Phillips, J. W. & C. J.
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Tilghman's Patent Sand Blast Co., Ltd.

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Phillips, J. W. & C. J.

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London Emery Works Co.

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London Emery Works Co.
Marshall & Co., Horace P.
Murphy, Stedman & Co., Ltd.
Phillips, J. W. & C. J.

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Marshall, H. P., & Co., Ltd.

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Hall, Charles, & Co.
Marshall & Co., Horace P.

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Samuelson & Co., Ltd.
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Lowood, J. Grayson, & Co., Ltd.

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Evans, J., & Co.
Hall, Charles, & Co.
Olsen, Wm.

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Evans, J., & Co.
Hall, Charles, & Co.
Wilkinson & Co., Thos., Ltd.

Stoppers and Nozzles.
Dyson, J. & J.

Straw Ropes.
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Hall, Charles, & Co.
Olsen, Wm.
Wilkinson & Co., Thos., Ltd.

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Evans, J., & Co.
Marshall, H. P., & Co.
Phillips, J. W. & C. J.

Time Recorders.
National Time Recorder Co.

Tuyeres (Firebrick).
Dyson, J. & J.
Lowood, J. Grayson, & Co., Ltd

Wire Brushes.
Wm. Olsen.

Telegrams: "ZACATECAS, ESTRAND, LONDON." Telephone: 6611 GERRARD (2 lines).

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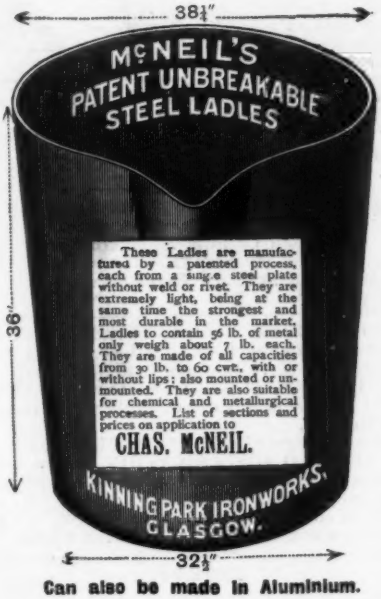
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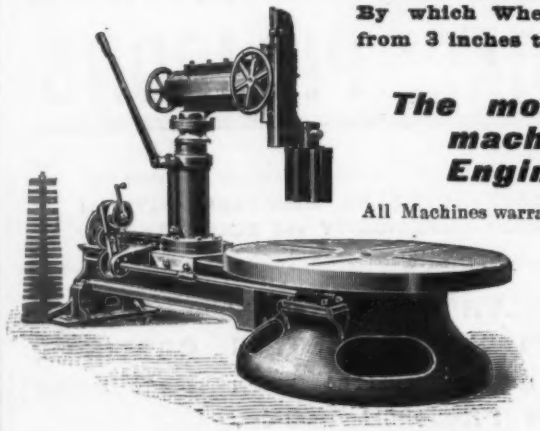

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